OPTIMUM ENTERPRISE ORGANIZATIONS FOR DAIRY FARMS WEST OF LAKE MARACAIBO, VENEZUELA

By

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Dedicated to all my dear friends west of Lake Maracaibo who are ultimately concerned about further developing the area. May the information contained herein be of usefulness to them.

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Chairman: Dr. Gerald O. Mott
Major Department: Agronomy

The study was conducted in a wet-dry area west of Lake Maracaibo, Venezuela. The area includes approximately 200,000 ha and is one of the principal dairying regions in the country. The majority of the pastures in the area is sown to guineagrass (*Panicum maximum*, Jacq.)

Due to a 4-5 month dry season in the region, there is an uneven forage supply throughout the year which requires that the farmers use some form of supplementary feeding during parts of the year. This situation was viewed with the cattle-forage-concentrate system in mind. Cattle alternatives which were considered were dairying and the purchase of beef bulls for further fattening. Forage alternatives included fertilization, hay making, silage making, deferred grazing, green chopping, and irrigation. The concentrate alternatives involved the production of crops such as corn, grain sorghum, soybeans and cassava; or the purchase of concentrate sources such as corn, grain sorghum, cassava, prepared concentrates, molasses, and a urea-molasses mix. The production of corn, grain sorghum, soybeans, cassava and guineagrass hay as cash crops was also considered.

The objective was to evaluate potential farming systems in the study area. Through this evaluation optimum enterprise organizations were developed for representative farm sizes of 150, 300, and 450 ha; and priorities were established for future research in the region.

Linear programming was first used to develop minimum cost feeding programs for specific livestock situations. The minimum cost feeding programs were then used as activities, along with the cash crop activities, in a second linear programming matrix which maximized net return for specific farm situations. The percentage of land under cultivation was varied for a 150 ha farm to see what effect it would have on net return and the organization of enterprises. A sensitivity analysis was run on the activities in the study.

Enterprise organizations were developed for 12 distinct farming situations. The use of commercially prepared concentrates so as to maintain production of the cows presently on the farms at a level of 6 liters/cow/day resulted in a substantial increase in net return for all three representative farm sizes. The net return could be increased further by placing up to 25% of a particular farm size under cultivation and purchasing additional cows. This required the use of much more capital, however.

Activities which consistently appeared in the more intensive farming systems were dairying, the purchase of additional cows, fertilization of pastures, hay made two times during the season, forage sorghum silage, soybean hay, cassava leaves, molasses, and a urea-molasses mix. The two cash crop activities which also appeared in the optimum farm plans were cassava and guineagrass hay. Green chopping and the use of cassava roots would have entered the solutions for the more intensive farming systems if their per unit costs of production had been reduced slightly.

Further research is recommended to verify the coefficients used in the study and to determine the feasibility of the activities which appeared in the optimum farm plans.

CHAPTER I

INTRODUCTION

One of the most serious problems facing farmers and ranchers in the wet-dry tropics, where cattle feeding is based almost entirely on forages, is the uneven feed supply throughout the year. There is commonly a surplus of feed during the wet season, with a corresponding shortage during the dry season.

This problem is complex and must be viewed with the cattle-forage-concentrate system in mind. The optimum solution, in most cases, does not involve a simple choice of one alternative as opposed to another but rather the putting together of a combination of alternatives. The use of fertilizer on pastures generally increases forage production during the wet season and helps to shorten the adverse effect of the dry season. However, the use of fertilizer alone often does not give an adequate solution to the problem. Forage supplies are often more fully utilized when combined with a forage conservation program, such as hay and silage making, or deferred grazing. It might also be profitable to add additional concentrate to the forage ration, but the form and level are often not known. Once the yearly feed supply has been increased and more evenly distributed, more animals are usually needed in the system to convert this added feed supply into additional production.

Aside from animal production in the wet-dry tropics, many farmers, who have ready access to markets, are also beginning to consider the feasibility of cash crops. These farmers would like to know which of the various cultivated crops would be most profitable and what portion of their farm resources should be allocated to this type of production.

Optimum enterprise organizations will be developed in this study for various representative farm sizes in a wet-dry area of the tropics. Linear programming will be the analytical tool used to develop these various farming systems.

This study is the result of a grant by the Ford Foundation in 1968 to the Center for Tropical Agriculture, University of Florida. The major objective of this grant was to develop year-round feeding systems for beef production in the wet-dry tropics. The University of Florida chose Venezuela as the Latin American country in which collaborative research was to be done on this problem. The basic goal of the project was to coordinate soil, plant, animal, and economic scientists of both countries into a team which would evaluate alternative systems of beef production. Alternatives to livestock production were also to be studied where land conditions and climate permitted.

A dairying region west of Lake Maracaibo, Venezuela, was chosen for the study. The reasons for choosing this particular site were many. Primarily, the proximity of this area to Maracaibo, Venezuela, the second largest city in the country and the location of the University of Zulia, provided this investigator with the opportunity of collaborating with many well-trained scientists in the country. This factor was considered essential for success of this study. Secondly, the region is in the wet-dry tropics and it was felt that information gained from this region could be applied to other areas of the tropics characterized by wet-dry conditions. Thirdly, the infrastructure was already present in this region, and many of the more modern production alternatives were already being used on a limited scale, making it possible to obtain the needed production coefficients. Lastly, it was felt that farmers in this region, due to their level of managerial development, would be capable of immediately applying recommendations resulting from this study.

In many farming situations in the wet-dry tropics use of many production alternatives that already exist could result in a two- to threefold increase in production. This would not only increase the net income of those farmers making the adjustments, but more importantly it would mean an immediate increase in food production to meet the ever-increasing demands of a rapidly growing world population. As a result of making these adjustments, new jobs are often generated that increase the purchasing power of other sectors of the society to obtain this badly needed food.

Aside from the immediate effects that a study of this nature can have on production in a particular area, it probably serves a more useful purpose by establishing priorities for future research. It should help in staking out areas where future research emphasis should be placed. We are witnessing the presence of many well-trained veterinary, animal, and plant scientists in the developing areas of the world today; and they want to know in what areas their efforts should be directed to have the largest impact in the shortest period of time. A systems approach, such as this, identifies those components that should go into farming systems. It is then the responsibility of the investigators in the area to do research on those specific components of the systems rather than dedicate their limited time and resources to other alternatives which are not as relevant at the present time.

Objectives of the Study

The overall objective of this study was to evaluate potential farming systems in the study area. In accomplishing this objective the applicability of linear programming in developing farming systems for the tropics will be demonstrated. It is anticipated that this approach will apply to other regions and situations in the tropics where it is desired to study problems of a similar nature.

The more immediate objective of this study was to determine the nature of enterprise organization on representative dairy farms in the region that will maximize net farm income, given a certain set of limited farm resources. Most profitable enterprise organizations were developed for three representative farm sizes in the area. This information should serve the useful purposes of establishing priorities for future research in the region and of providing guides to farmers in the area who must presently choose among alternative production opportunities. Although the information generated will not be directly applicable to any one farming situation, it will be easy to make adjustments in the set of restrictive resources so that they apply to a particular farm and give results for that particular set of circumstances.

Previous Research

Almost all published studies on dairy farm systems for the tropics have been conducted by Australian research workers. Swain (29) summarized the Australian studies which involved systems based generally on improved tropical legume-grass pastures which had been supplemented in some way with temperate pastures and forage crops. He questioned rather seriously whether a viable dairying industry can be maintained in the tropics if it has to rely on legume-grass pastures. He stressed the need for more investigations of farming systems in the tropics which are based on tropical grass plus nitrogen fertilizer and which involve diversified farming systems where dairy farming is only one of the components of the system.

The methods used to date to evaluate farming systems in the tropics have been quite varied. The surveying technique was employed by a group at the University of Zulia, Maracaibo, Venezuela (31,32) in the same region in which this study was conducted. This methodology appears to be effective in describing the present status of a region and in setting norms for comparing levels of management of one farm against another. It also serves a useful purpose of supplying input information for studies to develop optimum enterprise organizations.

The budgeting technique has been used on a number of occasions to develop and compare alternative systems of livestock production in the tropics (4,5,20). This approach has several advantages: it can be done by hand, is simple to use, and is easy to interpret. The disadvantage lies in that it usually forces one to arbitrarily combine certain practices at fixed quantities and, thus, limits the complexity of the problem that can be considered.

Linear programming has been used rather extensively in recent years to develop optimum combinations of enterprises for particular farm situations. Heady and Chandler (8) outlined the use of linear programming for profit maximizing problems in agriculture where intermediate products and purchasing activities are involved.

Studies in which linear programming has been used in the tropics to develop optimum enterprise combinations for farms where cattle and forages are involved are limited. Arroyo et al. (2) conducted a study in Chile where pasture and the fattening of steers were considered as possible alternatives in addition to other cash crop activities. In this study the intermediate product of pasture and the requirements of the fattening steers were expressed in terms of hectares of pasture. The pasture was considered to be of one type with no additional treatments to the pasture, such as fertilization, irrigation, or forage conservation. The ration of the fattening steers was limited to pasture with no additional grain or supplement considered as an alternative for satisfying the animals' nutrient requirements. In a study conducted in Colombia (6), animal unit months were used to link the pasture activities in the model with the cow-calf and bull fattening activities. The alternative of fertilizing the pasture was considered, but pasture was the only one considered for meeting the animals' nutrient requirements.

Jhunjhunwala (11) used linear programming to develop farming systems in Florida in which cattle and forage activities were considered. He used pounds of TDN as the unit of measure to link forage activities with cattle activities. Corn and hay were considered in addition to pasture for satisfying the animals' nutrient requirements. No provisions were made for changes in forage quality throughout the season, however, nor was a limitation placed on the daily feed intake of the animals.

Description of the Study Area

The study area is located in Venezuela on the western side of Lake Maracaibo at 10° N Latitude (Fig. 1). It is part of the area known as the basin of Lake Maracaibo.

The area includes approximately 200,000 ha. It begins at kilometer 40 south of Maracaibo and terminates in the south at kilometer 104 (Fig. 2). It is bounded on the east by Lake Maracaibo and on the west and northwest by the highway called "La Paz - El Laberinto." It does not include the low-lying areas around the principal rivers in the area and close to the lake on the eastern side. It also does not include the savanna area located around the town La Villa del Rosario. Politically it includes parts of the districts of Perija, Urdaneta, and Maracaibo.

The climate is sub-humid with the daily mean temperature varying between 27 - 34 C and the annual precipitation between 800 and 1400 mm (10). Fig. 3 shows the monthly distribution of rainfall including

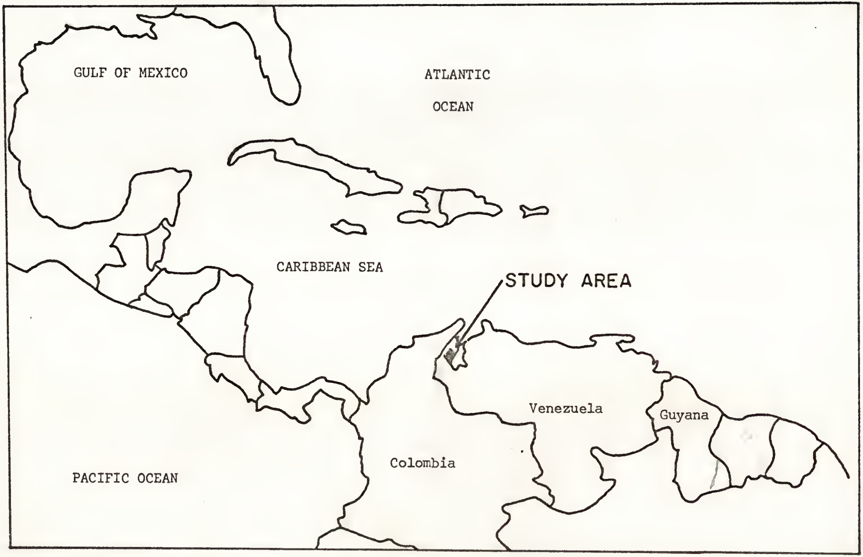

Fig. 1. Relative location of the study area.

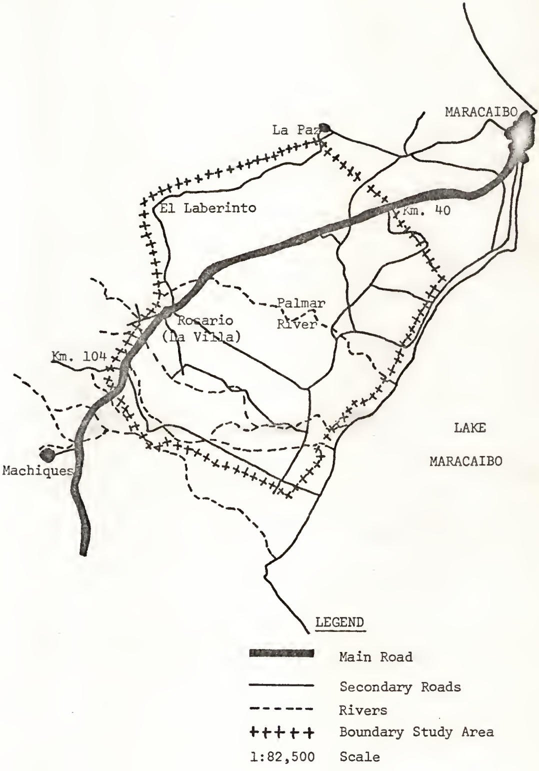

Fig. 2. Detailed map of the study area.

one standard deviation on each side of the mean. This graph was prepared from 25 years of data taken between the years 1943 and 1968 (15). As can be seen by the graph, the rainy season is from April through November, with the highest intensity during May and October. There are four seasons recognized in the zone. The long, dry season, which is called summer, lasts for 4 or 5 months usually beginning in December and ending sometime in April. The season of spring corresponds to the first rains which come in April and May. Following this there is a short dry season during June and July which is known as the Veranito de San Juan (Little Summer of St. John). The rainy season, which is called winter, usually begins in August and extends through November.

The soils are of lacustrine origin and would be classified according to the latest classification of soils as "Ultisols" (10). Since there are no important rivers that dissect the zone, the topography is very level with the slope never going above 6%. The natural fertility of these soils is low due to the severe weathering and leaching they have undergone over time. The pH is low, usually between 4.5 and 5.5. Base saturation is also low, being less than 35%. The drainage is generally good and sometimes somewhat excessive since the textures which predominate are sandy loam and loamy sand. The structure of the soils is not well developed; however a B horizon with a heavy accumulation of clay is generally found in all soils in the area. The biological activity is moderate, with the effective depth going as far as 100 cm. The most limiting factors in these soils are acidity and low fertility.

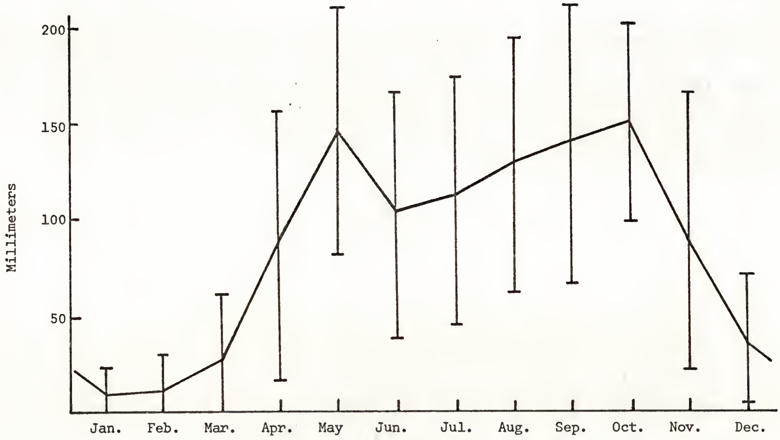

Fig. 3. Monthly distribution and variability of rainfall in the study area.

This area is one of the principal dairying regions in the country. The majority of the herds found in the area are of mixed breed involving crosses of the native cattle of Spanish origin with Brown Swiss, Holstein, and Zebu. The majority of the bulls are crossbred and come from the same area or other dairying regions in Venezuela. Some artificial insemination is used with the semen being imported from the United States. It is a general feeling among the farmers of the area that the European blood (Brown Swiss or Holstein) should not exceed 75% in the herd due to the stress that the animals are exposed to in terms of heat, insects, and diseases.

Most of the farmers follow a relatively strict program with the animals in regard to insect and disease control. Cows and heifers are usually vaccinated and checked against brucellosis and leptospirosis. All animals are vaccinated every 6 months against septicemia, aftosa (foot and mouth disease), and paralytic rabies. Every 6 months they are given treatment for internal parasites. The animals are sprayed at least once a month to control external parasites, particularly the tick.

The cows are milked two times a day. The first milking begins around 3 a.m. and is finished around 6 a.m., with the second milking commencing at 3 p.m. and terminating at 6 p.m. The cow is milked with the calf at side. The calf is allowed to nurse the cow for a short time before milking in order to stimulate milk flow. The calf is then tied to a front leg of the cow and the cow is milked by hand, leaving one teat for the calf to nurse after the cow has been milked. In this manner the production usually averages about 4 liters/cow/day, dropping as low as 2 to 3 liters in the dry season and as high as 6 to 8 liters during the rainy season when there is an abundance of forage.

Most of the improved pastures in the area have been sown to guineagrass (Panicum maximum, Jacq.). The pastures vary in size from 8 to 20 ha. A system of rotational grazing is used with the pastures. The cows in production are usually given priority and turned into a pasture first. After they have eaten most of the better feed, during a period of 5 to 10 days, they are followed by the dry cows, replacement heifers, and steers. It is general practice to turn the cows in one pasture during the day and another pasture at night. The resting period for a particular pasture will vary between 30 and 80 days depending on the time of year, the number of cows, and the number of pastures in the system. In the spring, when the rains commence, it is common for farmers to run an Argentine roller or rotary mower over the pastures to knock down old grass and brush that have accumulated over the year. It is also an approved practice to apply herbicide and insecticide to the pastures as needed.

The farmers are forced to use some form of supplementary feeding during the 4-month dry season to try to maintain production. There are a few farmers who are using silage made from guineagrass or forage sorghum, but the majority prefer the easier approach of using prepared concentrates with 16 - 25% protein which they buy from the feed companies in the area. They usually feed around 2 kg per cow per day during the dry season mixing this concentrate with a water-molasses mixture before giving it to the animals. During the rainy season many farmers feed no concentrate at all, while some feed a small quantity, usually not exceeding 1 kg per cow per day. The concentrate costs between 4 and 5 cents per pound and often is not effective in maintaining production. Common salt and a small quantity of a mineral mixture are usually given to the animals during the entire year. These are fed separately or mixed with a molasses-water mixture.

The main products marketed in the area are whole milk or cheese, and beef. Income from milk represents approximately 35% of the total farm income. It is used to cover the daily costs incurred on the farm such as wages, food, repairs, etc. Income from the sale of beef, which is usually done in groups of cull cows and steers, is used to pay off back loans and interest, and for reinvestment in the farm.

There are two large milk-drying factories in the area where a large part of the milk is marketed. Many of the farms located close to Maracaibo send their milk to one of the four pasteurized milk processing plants in the city. There is one factory in the area which buys milk to process into cheese and another which buys milk to be shipped to Caracas. A few of the smaller producers still process their milk into cheese on the farm. As the system of roads and transportation improves, this practice is gradually being eliminated.

With the nearness of the metropolitan area of Maracaibo, the farmers have no problem in acquiring needed machinery, supplies, and services. There are six major machinery dealers in Maracaibo.

Many repair parts and supplies are also available in the small towns located in the area. Small purchasing cooperatives are popular and have been formed in all sub-sectors of the area. These associations serve not only to aid farmers in acquiring supplies at reduced costs, but they also serve as centers for disseminating new information to them.

Velasco (34) did an excellent study on farm workers and owners in the area. Her survey indicated that about half the workers in the area are Colombians with only one-fourth of the workers being those known as Venezuelans. The remaining one-fourth of the working force consists of indigenous Indians who come from either Venezuela or nearby Colombia.

Velasco's study showed the instability of the working force, particularly the Colombian segment. Some 78% of the Colombian workers had spent less than 1 year on the particular farm where they were questioned during the survey. More than 60% of all workers questioned were illiterate. As pointed out by Velasco, these factors of instability and low educational level of the working force will definitely be a hindrance to future intensification of production in the area.

The owner situation is somewhat brighter. Of the owners that were questioned, 63% had occupied the position of owner on their particular farm for more than 10 years. This does not mean, however, that the position of owner is occupied by a group of very old farmers who are conservative and set in their ways. Almost 80% were found to be less than 50 years of age. More than 80% of the owners had as their sole occupation that of owner-operator of their respective farms. The educational level is relatively high, with only 15% of the owners questioned found to be illiterate. Better than 10% have college degrees but not necessarily in agriculture.

The only detrimental aspect of the farmers in the region, in respect to future intensification of production, is their level of knowledge about improved practices in agriculture. Better than 90% of them have never received any courses or formal training in agriculture. Their knowledge of agriculture is based mainly on that handed down from their fathers and from their own personal experiences on the farms. Velasco's study indicated, however, that the majority of the farmers in the region consider farming to be a business and show a strong desire to improve production practices. Differences arise only in the manner of accomplishing it. There seems to be a general readiness on the part of many to try new techniques, particularly in the areas of feed conservation and irrigation. Their hesitancy to use new techniques in many cases stems from lack of knowledge and sureness on their part that the technique will succeed in their particular situation.

CHAPTER II

DESIGN OF STUDY, DATA, AND ANALYTICAL PROCEDURE

In order to conduct a study of this nature and to develop systems that are relevant, it is of utmost importance that the investigator be thoroughly familiar with the area and people for which the study is made. With this in mind, a survey was first conducted of 80 farms in the area. Following the survey it was necessary to select those production alternatives and resource restrictions that seemed most appropriate and feasible for the area. Once the production alternatives were selected, a budget was prepared for each one, showing all income and variable expenses associated with each. The quantity of each restrictive resource that was used by each alternative was also determined. Once all these data had been obtained, they were analyzed by linear programming with the aid of the computer. With a given solution for a particular farm size, varying levels of resources and product prices were used to identify the economic and technical conditions under which these farm organizations undergo basic changes. Particular attention was given to identifying those alternatives which consistently appeared in the solution when levels of resources and product prices were varied over a wide range.

The Initial Survey

Since the majority of the farms in the study area were producing milk and beef, it was possible to obtain certain basic information from the whole and dried milk factories of the area and from the Ministry of Sanitation. Through these sources, the following information was obtained for the majority: (1) farm size in hectares, (2) total number of animals, (3) number of cows in production, (4) total annual milk production, (5) production during the wet season, and (6) production during the dry season. With this information it was possible to stratify the farms into representative sizes and to determine those in each representative size that would be included in the survey. In preference to selecting a randomized group of farms from the area to be surveyed, those with above average production records were selected to be surveyed from each size group. It was felt that a survey of the more productive farms in each size group would give a better idea of what is presently possible in the area and of what might be possible in the way of new alternatives in the future.

The survey had three basic objectives. The major objective was to become thoroughly familiar with the study area. This included not only the agronomic factors of production but human and economic factors as well. Every effort was made to become well acquainted with farmers of the area who, it was well understood, would be the decision makers for any future adjustments which might be made in production systems on the farms. An effort was made to know more about their basic ambitions in life, their level of technical skill and experience with machinery, their receptiveness to change, and their general attitude about more intensive production practices.

A second objective was to obtain information concerning resources that were restrictive and alternatives that should be included in the future study. The resources and activities that were presently in use were noted, and the farmers were asked to comment on what new practices they would consider using in the future to increase production on their farms. Attempts were made to determine institutional constraints imposed upon them such as availability of capital, availability of supplies and services, and accessibility and stability of markets for products that they might be able to produce.

The last objective was to locate farmers from which more detailed information could be obtained concerning the input-output relationships of the various alternatives to be included. The survey was successful in locating farms where new practices such as fertilization, irrigation, silage making, hay making, deferred grazing, green chopping, and the production of cultivated crops were already being employed.

Determination of Resource Restrictions

Based on the information obtained from the initial survey, representative farm sizes of 150, 300, and 450 ha were selected for this study. In addition to the surveys, area studies (31,32) and interviews with competent individuals in the area were used to determine those resources which should be considered restrictive for each farm size.

No provisions were made for differences in land quality which obviously existed but were felt to be of minor importance in this study. A study conducted by the Faculty of Agronomy, University of Zulia, (10) indicates that the soils throughout the area are rather uniform with respect to their chemical and physical properties. The soil in all situations was assumed to be of the Ultisol order, ranging in texture from a sandy loam to a loamy sand. It was further assumed that the entire area in each farm size was already in established guineagrass pastures.

Annual operating capital for the 150, 300, and 450-ha size farms was set at 23,000, 43,000, and 65,000 Bolivares, respectively. The rate of exchange was 4.5 Bs./U.S. Dollar at the time of this study. The limit on the amount of capital that could be borrowed by the three farm sizes of 150, 300, and 450 hectares was assumed to be 147,000, 261,000, and 396,000 Bolivares, respectively. These values represented 50% of the value of owned resources for each of the three farm sizes. It was assumed that the majority of this money would be borrowed from the commercial banks in Maracaibo, with a small part being borrowed from the milk processing plants and machinery dealers located in the study area. The interest rate was determined to be approximately 9% per year.

As explained in the study of Velasco (34), closeness to the Colombian border results in a large influx of undocumented Colombians who serve as the working force in the area. They can be hired on a permanent or temporary basis without difficulty. For this reason, day labor was not considered to be restrictive on any of the three farm sizes considered.

The number of tractor hours available to carry out the forage and crop production activities was considered to be limiting. Based on the survey, it was assumed that the farm sizes of 150 and 300 hectares would have only one tractor, while the farms of 450 hectares would have two. It was assumed that these tractors would be operated 8 hours a day Monday through Friday and 4 hours on Saturday morning. This is the normal work week for tractor drivers in the area. Provisions were made, however, for the farmers to purchase an additional tractor or two when it was deemed necessary for carrying out operations called for in a particular enterprise organization. It was assumed that the machinery inventory for all three farm sizes, in addition to the tractors, would consist of a rotary mower or Argentine roller, a trailer-mounted pasture sprayer for controlling weeds and insects, and an all-purpose trailer. Provisions were made in the program to purchase additional machinery and equipment as they were indicated by the various alternatives which came into the new organization of enterprises for a particular farm size.

The number of cows presently on the 150, 300, and 450 ha farms was set at 80, 130, and 200, respectively. The 150 and 300 ha farms were assumed to have one milking area which would accommodate 160 cows, while the 450 ha farm was assumed to have two sites for milking which would accommodate a total of 320 cows. Here again, provisions were made in the program to increase the size of the herd and area available for milking if the optimum system called for quantities different than those assumed to exist at the present time.

Selection of Production Alternatives

Since the area is presently a dairy region with beef being sold as a secondary product, this study was limited primarily to developing more nearly optimum systems for the production of milk and beef with due consideration for limitations that are imposed by the area. No attempt was made to determine the feasibility of producing other classes of livestock, fruits, or vegetables even though they might be more profitable. It was assumed that dairy and beef production would continue to predominate in the area due to tradition and the personal preferences of the farmers making the decisions. Provisions were made, however, for the introduction of a limited number of cash crops into the system if they proved to be more profitable than the traditional dairy and beef production.

The selected production alternatives were divided into four broad categories: (1) cattle alternatives, (2) forage alternatives, (3) concentrate alternatives, and (4) cash crop alternatives. The alternatives selected within each group of alternatives were based on their frequency of occurrence in the study area and their likelihood of being accepted and used by farmers in the future.

Cattle Alternatives

The cattle alternatives were limited to four. Two of them involved dairy cattle operations and the other two were concerned with beef fattening operations.

The dairy cattle operations considered the alternatives of selling bull calves produced on the farm at 1 1/2 years of age or of keeping them until they reach a market weight of 435 kg at 2 1/2 years of age. The budget for a 100-cow herd in which the calves are kept on the farm until they reach market weight is shown in Table 1. A weaning rate of 70% was assumed with 3% annual death loss for animals between 1 and 2 years of age and 2% annual death loss for all animals 2 years of age and older. All heifers were kept for their first lactation. Those not giving favorable results during their first lactation were culled along with old cows to maintain the milking herd at a constant number. The average cow for this study was assumed to produce 4 liters of milk per day which approximates the average presently in the study area. This resulted in 1,300 liters of salable milk per year after the calf's consumption had been subtracted out. Cows producing 6 liters of milk per day were also considered. The sale of calves, steers, and cull cows in these alternatives was conducted only at the end of the main wet season which coincided with the end of the calendar year. The cost inputs shown in the budget do not include feed requirements. The nutrient requirements for this alternative are shown separately, and will be satisfied by specific forage and concentrate alternatives to be mentioned later.

The two beef fattening alternatives involved a 6-month and a 12-month fattening program. In both cases the steers were bought from other farmers in the area at the end of the wet season. They weighed approximately 220 kg at this time. In the 6-month fattening program the steers were sold in July at a weight of 340 kg, while in the 12-month program they were sold at the end of the next wet season at a weight of 435 kg.

Table 1. Estimated production requirements and income for a 100-cow dairy herd; bull calves marketed at 2 1/2 years of age.

Item	Unit	Rate	Number	Price or cost per unit	Total quantity	Total value or cost	Value or cost per cow unit
				Bolivares[a]		Bolivares	Bolivares
(1) Livestock investment							
Mature cows	head	450 kg	100	1,000	100	100,000	
Breeding bulls	head	500 kg	3	2,000	3	6,000	
Replacement heifers	head	350 kg	33	800	33	26,400	
Heifers (coming 2 yr)	kg	285	34	1.50	9,690	14,535	
Beef bulls (coming 2 yr)	kg	285	34	1.50	9,690	14,535	
Weaned calves	kg	180	70	1.50	12,600	18,900	
Total investment						180,370	1,803.70
(2) Production							
Milk	liter	1,300	100	0.62	130,000	80,600	
Fat bulls	kg	435	33	1.70	14,355	24,404	
Cull cows	kg	400	31	1.40	12,400	17,360	
Total income						122,364	1,223.64
(3) Inputs							
Labor	m.d.	5	365	15.00	1,825	27,375.00	
Salt and minerals							
Cows, bulls and replacement heifers	kg	6.0	136	0.50	816	408.00	
Heifers and bulls (coming 2 yr)	kg	4.0	68	0.50	272	136.00	
Heifers and bulls (coming 1 yr)	kg	2.5	70	0.50	175	87.50	
Calves	kg	1.0	72	0.50	72	36.00	

Table 1. (Continued)

Item	Unit	Rate	Number	Price or cost per unit	Total quantity	Total value or cost	Value or cost per cow unit
				Bolivares		Bolivares	Bolivares
Veterinary and medical							
Cows, bulls, and heifers	Bs./head		274	2.65		726.10	
Calves	Bs./head		72	3.83		275.76	
Equipment depreciation	Bs.		1	1,000.00		1,000.00	
Bull depreciation	Bs.		3	300.00		900.00	
Power (gas or electric)	Bs.		1	1,200.00		1,200.00	
(4) Total specified costs						32,144.36	321.44
(5) Net return over specified costs						90,219.64	902.20
(6) Nutrient requirements							Requirement per cow unit
							kg
TDN							
Jan. 1-Apr. 30	kg				122,978		1,230
May 1-June 15	kg				49,226		492
June 16-Aug. 31	kg				87,742		877
Sept. 1-Dec. 31	kg				152,115		1,521
Crude protein							
Jan. 1-Apr. 30	kg				21,287		213
May 1-June 15	kg				9,766		98
June 16-Aug. 31	kg				15,578		156
Sept. 1-Dec. 31	kg				26,763		268

a/ 4.5 Bolivares = 1 U. S. dollar.

Forage Alternatives

It was assumed that all land on a particular farm size was already sown to guineagrass (Panicum maximum Jacq.). It was further assumed that a minimum of maintenance would be performed on these guineagrass pastures after which other alternatives could be added to the system. Those minimum maintenance activities consisted of pasture renovation once every 10 years, cleaning of the fence lines in November and December of each year, clipping of the pastures with a rotary mower or Argentine roller to control weeds once every 2 years, and spraying of the pastures with herbicide and insecticide once every 2 years. These were considered to be the minimum practices that the majority of the farmers in the area are presently using, and thus served as a base to which other alternatives could be added.

Fertilization, irrigation, hay making, silage making, green chopping, and deferred grazing were the improved practices considered in addition to maintaining the pastures. Fertilization, irrigation, and silage making are used by a number of farmers in the area. Green chopping was observed in the area on only two occasions while hay making was practically non-existent. One farmer in the area did own hay making equipment but did not use it during the time that this investigator was in the area. Hay was made on an experimental basis on two occasions to test out the feasibility of this alternative. It was found that it is possible, agronomically speaking, to make hay in the area but that there are certain technical problems regarding servicing of the baler which will need to be worked out if baling is to be the method of hay making in the future. Deferred grazing is not known as such by the farmers in the area although many of them practice it unknowingly by leaving long rest periods between grazings at the end of the wet season. The practice of deferred grazing in this study, however, implies that the pasture is especially prepared in the latter part of the wet season in order to leave standing hay of fairly good quality which can be used during the following dry season. This special preparation includes one pass over the pasture with a rotary mower during the period of October to November followed by the application of 200 kg/ha of urea. The pasture is not grazed until the period of January to April. This procedure was tested with ungrazed plots to check its feasibility and to obtain coefficients to be used in this study. One farmer was actually following this procedure and claiming beneficial results. It was assumed that hay or silage could be made on the same piece of land either one or two times during the September to December wet season. The use of the hay and silage was restricted to January to April and June to August. Each of these improved practices was considered both separately and in various combinations with the other practices. The combination of improved practices that were considered with the established guineagrass pastures is shown in Table 2.

In addition to those shown in Table 2, three additional silage alternatives were considered with guineagrass. The silage alternatives were normally considered to be accomplished using a bunker silo and forage equipment (forage harvester and wagons) that belonged

Table 2. Forage production alternatives using established guineagrass pastures.

Forage Production Alternative	Maintain Pasture	Fertilize Pasture	Irrigate Pasture	Make Hay (one time)	Make Hay (two times)	Make Silage (one time)	Make Silage (two times)	Green Chop	Deferred Graze
1	X								
2	X	X							
3	X		X						
4	X	X	X						
5	X			X					
6	X	X		X					
7	X		X	X					
8	X	X	X	X					
9	X				X				
10	X	X			X				
11	X		X		X				
12	X					X			
13	X	X				X			
14	X		X			X			
15	X	X	X			X			
16	X						X		
17	X	X					X		
18	X		X				X		
19	X							X	
20	X	X						X	
21	X			X				X	
22	X	X		X				X	
23	X				X			X	
24	X					X		X	
25	X					X		X	
26	X						X	X	
27	X								X
28	X	X							X
29	X			X					X
30	X	X		X					X
31	X					X			X
32	X	X				X			X

to the farm. Forage production alternatives 13, 17, and 32 were also considered utilizing custom services of farmers' associations or individual farmers in the area to make the silage. It was assumed that a portable Italian system known as the "Frigieri" system would be used in making the silage. This system was being promoted in the area. It consists of a steel, movable frame which serves to make a round stack of silage of 100 metric tons. The system comes completely automated with an elevator powered by a small gasoline engine, an automatic distributor, and a packing unit. The metal frame, distributor, and packing unit can be disassembled once the stack is completed, and moved to a new site where another stack of silage can be made. It was assumed that the organization or individual farmer that supplied custom service of filling the silo would also furnish the forage harvester, wagons, tractor power, and labor to make the silage.

A fourth additional alternative with guineagrass involved green chopping during the entire year. Green chopping normally took place only during the long dry season of January to April and the shorter dry season of July to August. Green chopping, in all cases, implied the use of irrigation in the dry seasons to maintain forage production.

Four additional forage alternatives were included that did not involve guineagrass. Three of these involved planting sorghum (Sorghum vulgare Pers.). In one case it was used for green chopping and in the other two for silage. It was considered that silage could be made in either the conventional manner using a bunker silo or through the hiring of someone to make it using the Frigieri system which was previously described. The fourth additional forage alternative involved planting corn to be made into silage.

Concentrate Alternatives

The concentrate alternatives fell into two main catagories. One involved concentrates being produced on the farm and later utilized in the system. The second entailed purchasing concentrates from outside sources to be used on the farm.

Those concentrate sources considered for production on the farm were ear corn, grain sorghum heads, cassava roots, cassava leaves, and soybean hay. Corn, grain sorghum, and cassava are well known in the area, and they are grown on a small scale. Soybeans have been tried only on an experimental basis, but they have been found to be adapted to the area (1). It is assumed that each of these crops would be harvested by hand and processed on the farm before utilization. All of them can be utilized at any time during the year. When any of these cropping alternatives enter into the system, they use land formerly in guineagrass production.

Concentrate sources which could be purchased included commercially prepared concentrates: corn, grain sorghum, cassava, molasses, and a urea-molasses mix. The latter is presently being sold by a private company in the area. The mix considered in this study consisted of 10% urea and 90% molasses. These concentrate sources could be used during any period of the year. The possibility of purchasing whole soybeans or soybean meal was not considered feasible at this time as there are no soybeans presently being produced in the area.

Cash Crop Alternatives

The cash crops which could be grown and later sold on the open market were limited to five: corn, grain sorghum, cassava, soybeans, and guineagrass hay.

It was assumed that the corn would be harvested by hand. It would later be sold to other farmers in the area or to the two large feed companies located in Maracaibo.

It would be necessary to custom-hire the harvesting of the grain sorghum with combine harvesters. This service is available in the area so it would pose no real problem. The market for grain sorghum would be similar to that for corn with the sorghum being sold to local farmers or feed dealers in Maracaibo.

It was assumed that the cassava roots would be harvested by hand. They would be sold to buyers in the area who would later sell them in Maracaibo on the fresh market or in the town of Agua Viva where a processing plant for cassava is located. The leaves of the cassava plants were considered to be available as a concentrate source on the farm after the roots had been harvested.

The harvesting of the soybeans would also have to be custom-hired. They could be marketed in the central part of the country in the city of Valencia where extracting plants are presently located. As there are good roads between the study area and Valencia, it would not be any problem to contract someone from Maracaibo to truck them to Valencia.

It was assumed that the hay would be sold to other farmers in the area. In this situation where hay was being produced as a cash crop, the land was used solely for the purpose of making hay four times during the year.

Preparation of the Budgets

The input data for this study were compiled in the form of enterprise budgets. Fifty-four budgets were developed for the different cattle, forage, concentrate, and cash crop alternatives that were considered. The budget for the dairy cow alternative in which bull calves were sold when they reached market weight was presented in a previous section (Table 1). Table 3 is the budget prepared for fertilizing, irrigating, and making silage one time during the year on a ha of established guineagrass. The budget that was prepared for the production and on-the-farm use of a ha of corn is shown in Table 4. When the alternative was to be used in the system and later marketed as milk or meat, as was the situation with both of the enterprises shown here, the return was expressed in terms of total digestible nutrients (TDN) and crude protein (CP) rather than in monetary terms. The values which are shown in Table 3 for grazable forage represent the quantity of those nutrients which would be available by time period after the silage had been made. An itemized listing was made of all variable expenses including the labor and tractor hours required for each operation and the dates when they would normally be performed. The budgets for all of the 54 enterprise alternatives are available in a separate publication which may be obtained upon request from the Department of Food and

Table 3. Estimated production and annual costs per hectare of fertilizing, irrigating, and making silage one time per year from established guineagrass pasture.

Item	Unit	Price or cost per unit	Quantity	Value or Cost
		Bolivares		Bolivares
(1) Production				
Silage				
Wet weight	ton		20	
TDN	kg		2,415	
Crude protein	kg		360	
Grazable forage				
TDN				
Jan. 1-Apr. 30	kg		1,531	
May 1-June 15	kg		1,150	
June 16-Aug. 31	kg		1,310	
Sept. 1-Dec. 31	kg		1,310	
Crude protein				
Jan. 1-Apr. 30	kg		342	
May 1-June 15	kg		299	
June 16-Aug. 31	kg		288	
Sept. 1-Dec. 31	kg		288	
(2) Specified variable expenses				
Pasture maintenance	ha	94.00	1	94.00
Clipping of pasture (biannually)	ha	30.00	0.5	15.00
Urea (46% N)	kg	0.48	850	408.00
Applic. of urea (split application)	ha	20.00	2	40.00
Harvesting forage	ton	3.50	20	70.00
Filling of silo	ton	420	20	84.00
Silo cover (plastic)	ton	1.58	20	31.60
Molasses	kg	0.20	268	53.60
Irrigating				
Labor	man days	15.00	13	195.00
Power	ha	95.00	1	95.00
Repairs	ha	75.00	1	75.00
(3) Total specified costs				1,161.20

Table 4. Estimated production and annual costs per hectare of corn for on-the-farm use.

Item	Unit	Price or cost per unit Bolivares	Quantity	Value or Cost Bolivares
(1) Production				
Earcorn	DM,kg		3,000	
TDN	kg		2,550	
Crude protein	kg		279	
(2) Specified variable expenses				
Plowing	ha	40.00	1	40.00
Disking	ha	20.00	2	40.00
Seed	kg	2.35	15	35.25
Planting	ha	20.00	1	20.00
Urea (46% N)	kg	0.48	300	144.00
Triple superphosphate (45% P_2O_5)	kg	0.36	100	36.00
Applic. of fertilizer	ha	20.00	1	20.00
Herbicide (Atrazine)	kg	39.00	2	78.00
Applic. of herbicide	ha	10.00	1	10.00
Cultivation	ha	30.00	1	30.00
Insecticide (Endrin 19.5%)	liter	9.00	4	36.00
Applic. of insecticide	ha	10.00	2	20.00
Harvesting (by hand)	ton	41.00	3	123.00
Drying	ton	20.00	3	60.00
Sacks	each	1.00	60	60.00
Farm transport	ton	10.00	3	30.00
Fumigation	ton	10.00	3	30.00
Grinding and mixing	ton	20.00	3	60.00
Fence depreciation	meter	0.13	125	16.25
Fence cleaning	ha	4.50	1	4.50
(3) Total specified costs				893.00

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It was assumed that the most advanced techniques of production that are presently available in the area would be used in all production alternatives even though only a small percentage of the farmers in the area may be using this level of technology at the present time. Since the results of this study indicate the production and income potentials of farmers in the region that are willing to adopt higher levels of technology, this assumption is appropriate. Furthermore, the use of a lower level of technology would have implied under-utilization of resources which could be detrimental to the economic development of the study area.

The data for the budgets were supplied in part by specific studies that had already been carried out in the study area (1,12,25, 26,30,31,32,33), and by more general studies that were related to all of Venezuela (13,14,27). Studies which had been conducted in other neighboring Latin American countries also served as sources for certain needed coefficients (3,6). In certain instances simple experiments were conducted to get the needed information. Since there were very few data on the use of fertilizer on pastures, small plot experiments were conducted at four different sites in the study area using various levels of N, P, and K. These experiments provided useful data for the fertilization, silage making, hay making, and green chopping alternatives. Two small plot experiments were conducted to obtain more data for the deferred grazing alternatives. Four experiments were run with corn to study the possibility of planting with machinery and the use of fertilizer with different varieties and hybrids. Different varieties of grain sorghum, forage sorghum, and soybeans were also tested at one site in the area in an attempt to have more accurate coefficients for these alternatives. The farmers that were already using such practices as irrigation, silage making, and green chopping furnished much-needed information concerning the inputs that went into those production alternatives.

Total digestible nutrients and crude protein were used to relate cattle enterprise feed nutrient requirements to the output of forage and concentrate production alternatives. Although TDN is not the only means of expressing energy content of tropical forages, it was the only unit of measure that was readily available for the numerous alternatives that were being considered. Since in many cases TDN has been calculated from metabolizable energy which had been previously calculated from net energy (21,p.4), the results for this study would probably not have varied greatly had another energy term been used. The TDN and CP values were obtained, in most part, from the feed composition tables prepared by the National Research Council (21,22). The data for cassava were obtained from Morrison's feeding tables (17), while the values for corn silage and forage sorghum were taken from work done in Hawaii (28) and the National Research Council tables. To determine the production of TDN and CP for fertilized and unfertilized guineagrass pastures under grazing, data from grazing trials which had been conducted in Brazil (23,24) were used as a guide. A comparison of the area in Brazil with that of the study area indicated that there was sufficient similarity between the two regions to justify use of the data. Values for cut guineagrass forage in the form of hay, silage, or green chop were set at 50% TDN and 8% CP on a dry matter basis. These values were based on work done by Gonzalez (7) at Maracay, Venezuela, and from information obtained from small plot experiments in the study area.

Procedure of Analysis

To develop optimum farm plans for representative farm sizes, it was necessary to divide the analysis into two parts. Linear programming was first used to develop minimum cost feeding programs which would satisfy the nutrient requirements of the different cattle alternatives. The minimum cost matrix is presented in the appendix as Table 6. Once the minimum cost feeding programs had been developed, they were used along with the different cash crop alternatives in a second linear programming routine to maximize net revenue for a particular farm resource situation. The matrix used in the net revenue maximization problem is presented in appendix Table 12.

Development of Minimum Cost Feeding Programs

In the minimum cost matrix (Table 6), only TDN and CP were considered. The mineral requirements were not considered since provisions had been made in the livestock budgets for minerals to be fed free choice. A limitation was placed on the intake of dry matter by each livestock alternative, and the quantity of dry matter that each forage or concentrate alternative would supply was listed in relation to the TDN and CP that it was supplying to the system. The CP that could come from urea was limited to one third of the total CP requirements of each cattle alternative. Row entries were established in the matrix for the TDN and CP that came from hay and silage. Hay and silage could not be used to satisfy the cattle nutrient requirements unless they had previously been produced by one of the hay or silage producing activities. The values which are shown in the minimum cost matrix were taken from the enterprise budgets which were previously described.

The feeding programs that were developed through the use of the minimum cost matrix are shown in the appendix as Tables 7 to 11. The feeding programs shown in Table 6 were developed using column 89 for the right hand side which represents the requirements for milk cows producing 4 liters of milk per day and the sale of bull calves produced on the farm at 1 1/2 years of age. Feeding program No. 1 was developed using column 89 of the matrix in combination with all of the forage and concentrate alternatives (columns 1-83). Feeding program No. 2 differed from feeding program No. 1 in that the columns that involved silage making were not allowed to enter the programming solution. Likewise, columns in the matrix that involved the production of concentrates on the farm were not considered in feeding program No. 3 and neither silage making nor the production of concentrates was considered in program No. 4.

Tables 8 to 10 follow a similar pattern to that explained for Table 7 with the exception of the column which was used as the right hand side for each table. Column 88 of the minimum cost matrix was used as the right hand side for developing the feeding programs in Table 8; column 87 was used as the right hand side for developing Table 9; and column 86 was used as the right hand side in the case of Table 10.

Table 11 was developed by using the combined requirements of two of the cattle alternatives to develop each of the feeding programs. Feeding program No. 17 in Table 11 was developed to satisfy the nutrient requirements of the dairy cow alternative in which the cows are producing 4 liters of milk per day and the bull calves produced on the farm are marketed at 2 1/2 years of age (column 88). It was combined with the purchase of bulls for fattening in a 6-month fattening program (column 84). Feeding program No. 18 was developed to satisfy the requirements of column 85 combined with those of column 88; No. 19 involved the combination of column 84 with column 86; and No. 20 involved the combination of column 85 with column 86. All forage and concentrate alternatives were considered in developing these feeding programs.

Separate feeding programs were developed for the fattening of purchased bulls in both the 6- and 12-month fattening programs, but the net return after feed costs had been considered was so low that these feeding programs were discarded. This resulted in the fattening programs being considered only in combination with the dairy cow programs.

A sensitivity analysis was run on the activities in the minimum cost feeding programs for cows producing 4 and 6 liters of milk/cow/day (Table 21). The feeding programs correspond to feeding programs 5 and 13 which were previously discussed.

The purpose of this analysis was twofold. The first purpose of the analysis was to give some indication of the decrease in cost that would be necessary for the activities that had not entered the optimum solution to become a part of the minimum cost feed program. This type of information is valuable in identifying those activities which would have entered the solution if their unit cost had only been reduced by a slight amount. Since all of the values which appear in this study were estimated, there usually exists a certain percentage of error in those estimates; those activities which almost entered the solution should probably receive as much emphasis in terms of priorities for future research as do those which actually did appear in the solution. The second purpose of the analysis was to give some indication of how much the cost of those activities which entered the optimum solution would have to be increased in order for some other activity to replace them. Those activities which, with a slight increase in cost, would leave the optimum solution were considered to be very sensitive and less stable than those activities which would require a large percentage increase in their unit cost before they would leave the solution. In making long-range plans for an enterprise organization, one would be looking for those activities which would require a large increase in unit cost before they would leave the solution to be replaced by another activity. This should add more stability to the system and thus eliminate the need for future costly adjustments in the enterprise organization.

Development of Optimum Farm Systems

The linear programming matrix which was used to develop the optimum farm systems by maximizing net revenue is shown in the appendix as Table 12. The 20 minimum cost feeding programs which were developed in the previous section were considered as activities along with the cash crop activities of producing corn, grain sorghum, soybeans, cassava roots, and hay for sale on the open market. An activity was included to buy more cows if they were needed, and another was included to borrow more capital up to the limit of the borrowing capacity of the particular farm size in question. Net return for the buy more cows activity (column 26) is expressed through the various feeding programs that use the cows.

Optimum enterprise organizations were developed for the six situations which are shown as right hand sides in the last page of the matrix. Column 28 was used in combination with columns 1 through 8, 17, 18, and 21 through 27 of the matrix to develop an optimum enterprise organization for a 150-ha farm in which the cows were at a production level of 4 liters per cow per day, and cultivated land was limited to 35 ha. The enterprise organization that was developed using column 29 differed from that developed using column 28 in that the minimum cost feeding programs involving silage making (1,3,5,7,17, and 18) were not allowed to enter the solution. Column 30 was used in combination with columns 9 through 16 and 19 through 27 to develop an optimum enterprise organization for a 150-ha farm in which the cows were at a production level of 6 liters per cow per day and cultivated land was not restricted. The optimum plan that was developed, using column 31 in combination with the same columns that were used with column 30, represented a situation in which the cows were at a production level of 6 liters per cow per day, the restriction on borrowed capital was relaxed to 500,000 Bs., and cultivated land was limited to 35 ha. Column 32 was run in combination with the same columns that were used with column 28 to develop a plan for a 300-ha farm in which the cows were at a production level of 4 liters per cow per day, and cultivated land was restricted to 75 ha. Column 33 was also run in combination with the same columns that were used with 28 to develop an optimum enterprise organization for a 450-ha farm in which the cows were at a production level of 4 liters/cow/day, and cultivated land was limited to 115 ha.

In the development of the six plans identified above, the sale of hay was limited to the quantity which could be produced on 20 ha of land and the sale of cassava roots was limited to the quantity which could be produced on 5 ha of land. This was done due to uncertainty of a market for large quantities of these two products. It was assumed that all of the farming situations would be limited to one complement of hay making equipment which would be capable of making 70 ha of hay per year. It was further assumed that they would not purchase more than one complement of silage making equipment which would be capable of making 20 ha of forage sorghum silage per year. Feeding programs which used cassava leaves were not permitted to enter the various solutions unless the sale of cassava roots activity had already entered the solution.

Six enterprise organizations were first developed using the limitations on borrowed capital that were previously mentioned for each representative farm size. The complement of machinery that would be needed to carry out the activities appearing in the first solution for a particular farm size was then determined, and the capital needed to purchase that complement of machinery was calculated using the data shown in Table 13. The limitation on borrowed capital was then adjusted downward to allow for the purchase of the needed machinery and a second run was made. If the enterprise organization changed in the second run to include a different set of machinery, the process was repeated until the provisions for investment in machinery were consistent with the machinery that was actually required in the optimum solution for a particular farm size.

In addition to the six enterprise organizations mentioned above, basic farm plans were also developed, by hand, for the three representative farm sizes with cows producing 4 liters of milk per day and with cows producing 6 liters of milk per day. Neither forage improvement activities nor the production of concentrates for use on the farm was considered. Only pasture maintenance activities were allowed. The number of cows on each farm size was limited to 80, 130, and 200 for the farm sizes of 150, 300, and 450 ha respectively, with no additional cows being purchased. Where extra protein was needed to supply the cows' nutrient requirements during certain times of the year, prepared concentrates were purchased. Concentrate was fed in combination with a small quantity of molasses as is the custom in the area (90% concentrate and 10% molasses).

The area under cultivation on a 150-ha farm was allowed to vary from 0 to 50 ha to see what effect it might have on net return to land, labor, capital, management, and risk. Also observed was the change which took place in the quantity of each of the cultivated crops as the total area in cultivated crops was varied. In this particular situation the production level of the cows was assumed to be 4 liters per day; and all forage, concentrate, and cash crop alternatives were allowed to enter the solution.

Since the sale of corn, grain sorghum, and soybeans had not appeared in the optimum enterprise organizations when the cultivated land was limited to 25% or less of the total in the farm, an analysis was made to see what change would be needed in net return per ha for these crops in order for them to enter the solution. This analysis was made for the 150 ha farm with cows producing 4 liters of milk per day and with the land under cultivation limited to 30 ha. There was interest also in determining the change that took place in the enterprise organization of the farm as the net return per hectare for a particular crop increased. An increase in net return per hectare for a particular crop could represent either an increase in market price of the crop, an increase in yield, or a decrease in variable expenses associated with the production of a hectare of that crop. It is also possible that it could involve a combination of these three factors.

In summary, the steps which were taken in this study are the following:

(1) Survey of the area.

(2) Determination of resource restrictions.

(3) Selection of production alternatives.

(4) Preparation of enterprise budgets.

(5) Analysis of data.

   a. Development of minimum cost feeding programs for specific livestock situations.
   b. Development of optimum enterprise organizations for specific farm situations.
   c. Evaluation of the effect of changing the quantity of land under cultivation.
   d. Determination of the sensitivity and stability of the alternatives in the study.

CHAPTER III

RESULTS OF ANALYSIS

Comparison of Optimum Farm Systems

The enterprise organizations which correspond to the 12 farm systems shown in Table 5 are shown in appendix Tables 14 to 20. The enterprise organizations for farm systems 1, 2, 7, 8, 10, and 11 are shown in Table 14 of the appendix. They represent the basic plans for the three representative farms. The guineagrass pastures are being maintained, but no additional forage improvement or concentrate producing activities are being performed. Farm systems 1, 7, and 10 represent situations in which the cows are at a level of production of 4 liters of milk per day, while farm systems 2, 8, and 11 represent situations in which the cows are at a production level of 6 liters per day. The enterprise organization for farm system 3 is shown in Table 15 of the appendix while the enterprise organization for farm system 4 is shown in Table 16. Both farm systems are for a 150-ha farm with cows that are producing 4 liters of milk per day. In farm system 3 both hay making and silage making are considered as forage conservation practices, while in farm system 4 only hay making is considered. Farm systems 5 and 6 are also for a 150 ha farm, but they are for cows that are producing 6 liters of milk per day. The enterprise organizations for farm systems 5 and 6 are found in appendix Tables 17 and 18, respectively.

Table 5. Comparison of optimum farm systems for the study area.

Item	Unit	Farm System					
		1	2	3	4	5	6
Farm size	ha	150	150	150	150	150	150
Cows in production	cow	80	80	100	114	294	80
Ave. milk production/cow/day	liter	4	6	4	4	6	6
Land in cultivated crops	ha	0	0	29.6	26.4	12	91.4
Total capital required	1000 Bs.	45.22	55.72	170	170	616.15	170
Investment capital required	1000 Bs.	0	0	122.90	114.35	424.05	107.85
Livestock	1000 Bs.	0	0	21.00	35.70	288.90	0
Machinery and Install.	1000 Bs.	0	0	101.90	78.65	135.15	107.85
Net return	1000 Bs.	11.75	25.97	36.33	33.89	75.25	55.20
Daily living expenses	1000 Bs.	20.00	20.00	20.00	20.00	20.00	20.00
Excess available to pay principal on investment capital	1000 Bs.			16.33	13.89	55.25	35.20
Length of loan needed	year			7.50	8.25	7.75	3.0
Net return over 10-year period	1000 Bs.	117.5	259.7	240.82	224.31	224.31	446.40
Appendix table showing enterprise organization		14	14	15	16	17	18

Table 5. (Continued)

Item	Unit	Farm System					
		7	8	9	10	11	12
Farm size	ha	300	300	300	450	450	450
Cows in production	cow	130	130	203	200	200	341
Avg. milk production/cow/day	liter	4	6	4	4	6	4
Land in cultivated crops	ha	0	0	72	0	0	103
Total capital required	1000 Bs.	77.15	94.22	304	117.94	144.20	461
Investment capital required	1000 Bs.	0	0	218.00	0	0	324.40
Livestock	1000 Bs.	0	0	76.65	0	0	148.05
Machinery and Install.	1000 Bs.	0	0	141.35	0	0	176.35
Net Return	1000 Bs.	13.98	37.08	69.60	22.56	58.10	105.27
Daily living expenses	1000 Bs.	20.00	20.00	20.00	20.00	20.00	20.00
Excess available to pay principal on investment capital	1000 Bs.			49.60			85.27
Length of loan needed	year			4.5			4.0
Net return over 10-year period	1000 Bs.	139.98	370.80	472.80	225.60	581.00	711.62
Appendix table showing enterprise organization		14	14	19	14	14	20

In farm system 5 the limitation on borrowed capital was relaxed, while in farm system 6 the restriction on the land in the farm that could be put in cultivated crops was relaxed. These were the only two systems that would utilize all of the land on the farm when considering 6-liter cows. Either the limitation on borrowed capital had to be relaxed or a greater percentage of the farmland had to be put under cultivation. This was due to the large amount of capital that was required to purchase additional cows which would produce 6 liters of milk per day. Putting a hectare of established guineagrass pasture under cultivation actually required less capital than that required to purchase additional cows to graze the pasture. Farm systems 9 and 12 were developed for representative farm sizes of 300 and 450 hectares respectively. The enterprise organizations which correspond to them are found in the appendix as Tables 19 and 20. These two farm systems are similar to farm system 3 in that the production level was set at 4 liters/cow/day and both hay making and silage making were considered as forage conservation possibilities.

In evaluating the enterprise organizations developed for the more intensive farming systems (Tables 15 to 20), it is interesting to note that certain activities consistently appear. With respect to the cattle activities, the alternative of marketing the bull calves produced on the farm at 2 1/2 years of age was preferred to selling them at 1 1/2 years of age so long as the cows were producing only 4 liters of milk per day (Tables 15, 16, 19, and 20). Once the production level was increased to 6 liters per cow per day, it became more profitable to sell the bull calves at 1 1/2 years of age rather than keep them on the farm for another year (Tables 17 and 18). This would release capital which could be used to purchase more of the higher producing cows, and would result in more forage being available for the higher producing cows to eat. In all cases additional cows were needed to more fully utilize the feed that was being produced in the systems. As far as forage activities are concerned, fertilization of pastures, making hay two times during the year, and making silage from forage sorghum consistently appeared in the more intensive systems. The concentrate activities which consistently appeared in the final solutions were the production of soybeans to be used as a concentrate source in the form of soybean hay, the use of cassava leaves after the roots had first been harvested, the buying and feeding of molasses and a urea-molasses mix, and the production and purchase of corn to be used as a concentrate source. In some cases the area to be devoted to the production of corn was so small that it would probably be more practical to purchase the corn required by the system rather than try to produce such a small quantity of the activity. As far as the cash crop activities were concerned, the production and sale of fresh cassava roots and hay consistently appeared in the solutions of the more intensive systems.

Farm systems 1 through 6 in Table 5 give a good comparison of the systems that were developed for a 150-ha farm. It is obvious that farm system 1 would not result in a net return which would be sufficient to cover even the minimum daily living expenses of the farmer and his family. This system was one of the simplest, and it involved only the activities of pasture maintenance and the use of purchased concentrates to maintain the production of the cows that are presently on the farm at a level of 4 liters of milk per day. Farm system 6 indicates that the net return to land, labor, capital, management, and risk over a 10-year period would be the greatest if the production per cow was maintained at 6 liters of milk per day and 91.4 ha of the 150-hectare farm were put under cultivation. The net return over a 10-year period of 446,400 Bs. looks very attractive. However, the question must be asked whether the farmers would be willing to take the risk, and whether they would have the technological know-how at this stage of development to put better than 60% of their farm under cultivation. If farm system 6 is eliminated, the next best system appears to be system 2 which simply involves the purchase and use of additional prepared concentrates so as to maintain the production of the cows which are presently on the farm at a level of 6 liters per cow per day. Practically the same net return could be obtained over a 10-year period with cows in which production was held at 4 liters per cow per day (farm system 3), but it would be necessary to put 20% of the farm under cultivation and to invest three times more capital than is needed in farm system 2. Considering the additional risk involved to do this, farm system 2 may be the preferred system for many farmers in the area. A comparison of system 4 with system 3 shows that limiting the forage conservation activities to hay making only (system 4), as opposed to both hay making and silage making (system 3), will cause a slight decrease in the net return over the 10-year period. Farm system 5 indicates that a respectable net return can be made over a 10-year period with 6 liter per day cows and a small percentage of the farm under cultivation. However, it would require about 3 1/2 times more capital than it is assumed that the operator of a 150-ha farm would be able to borrow. The capital is required to purchase 214 additional cows needed in the system. There exists some element of doubt as to whether this number of cows would even be available for purchase in the area.

Farm systems 7, 8, and 9 of Table 5 show the comparisons that were made with the 300-ha farm. Systems 7 and 8 are the basic plans that were developed for production levels of 4 and 6 liters/cow/day, respectively. It can be seen that the net return to land, labor, capital, management, and risk over a 10-year period increases by 2 1/2 times by simply maintaining the production of the cows at 6 liters per day instead of 4 liters per day. Farm system 9 indicates that the net return over a 10-year period can be further increased with 4-liter cows by putting 72 ha of the farm under cultivation and by purchasing 73 additional cows. Three times more capital would be required to carry out this plan.

Farm systems 10, 11, and 12 of Table 5 show the comparisons that were made with the 450-hectare farm. Systems 10 and 11 are the basic plans that were developed for production levels of 4 and 6 liters per cow per day, respectively. It can be seen that the net return to land, labor, capital, management, and risk over a 10-year period also increases by 2 1/2 times by simply maintaining the production of the cows at 6 liters instead of 4 liters per cow per day. Here again, as farm system 12 indicates, the net return could be further increased with 4-liter cows by purchasing 141 additional cows and by putting 103 hectares of the farm under cultivation. This plan would require three times more capital than does the plan which simply involves the maintenance of the cows presently on the farm at a production level of 6 liters of milk per cow per day.

The additional plans that were developed for the 150-hectare farm (forage conservation restricted to hay only, production at 6 liters/cow/day with the limitation on borrowed capital relaxed, and production at 6 liters/cow/day with the restriction on the land under cultivation relaxed) were not developed for the 300- and 450-hectare farms as it was assumed that the same relationships would exist between plans as were found on the 150-hectare farm.

Effect of Increasing the Land Under Cultivation

Fig. 4 shows the effect that varying the land under cultivation of a 150-hectare farm has on net return. In this case, cows were considered to be at a production level of 4 liters of milk/cow/day and all forage and concentrate producing activities were allowed to enter the solution. The net return increases linearly until the land under cultivation reaches approximately 30 hectares at which time it starts to level off with only slight increases in net return thereafter. It was on the basis of this analysis that a restriction of 25% of the farm to cultivated crops was established. Farm systems 3, 4, 9, and 12 were then developed with this restriction being imposed. The small increases in net return associated with

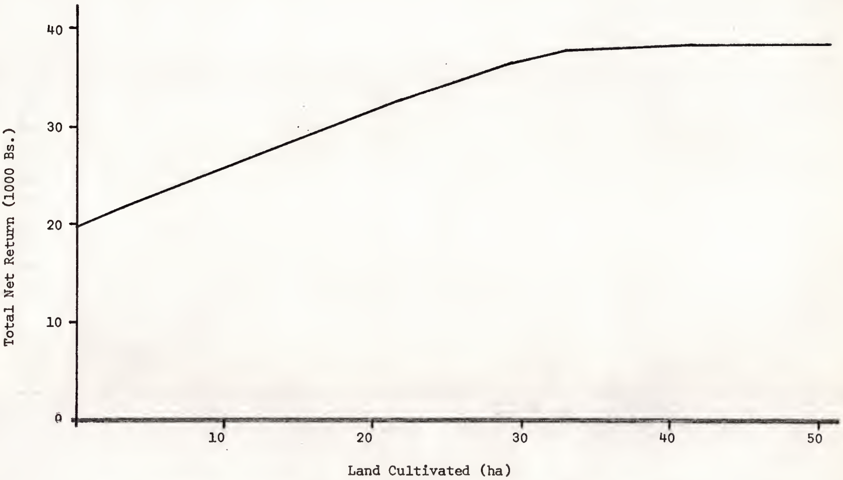

Fig. 4. Net return to land, labor, capital, management, and risk on a 150-hectare farm for variable quantities of cultivated land.

additional increases in cultivated land after 25% of the farm was in cultivation were not felt to be worth the extra risk and effort that would be involved in growing the additional cultivated crops.

Fig. 5 shows the changes that took place in the enterprise organization of the cultivated crops on a 150-ha farm as the land under cultivation was increased. The first 3 ha of cultivated crops were best utilized for forage sorghum grown for silage. As the land under cultivation increased, the hectares of forage sorghum remained rather constant while the growing of soybeans for hay and cassava for sale on the open market entered the solution in increasing amounts. The area in cassava reached the 5 hectare limitation when slightly over 20 ha were in cultivated crops. The area in soybeans continued to rise until 33 ha were under cultivation. The area in forage sorghum declined quite markedly when 30 ha under cultivation were reached, being replaced at first by more soybean hay and later by the production of corn for sale on the open market. The production of corn for sale entered into the solutions only after 33 ha were under cultivation. As the area under cultivation was increased beyond 33 ha, all additional cultivated land was most profitably used for corn production, and even some of the soybean and forage sorghum land was more profitably used by putting it into corn production.

Sensitivity and Stability of the Alternatives Considered

Table 21 of the appendix shows the results of the sensitivity analysis that was run on the minimum cost feeding programs developed

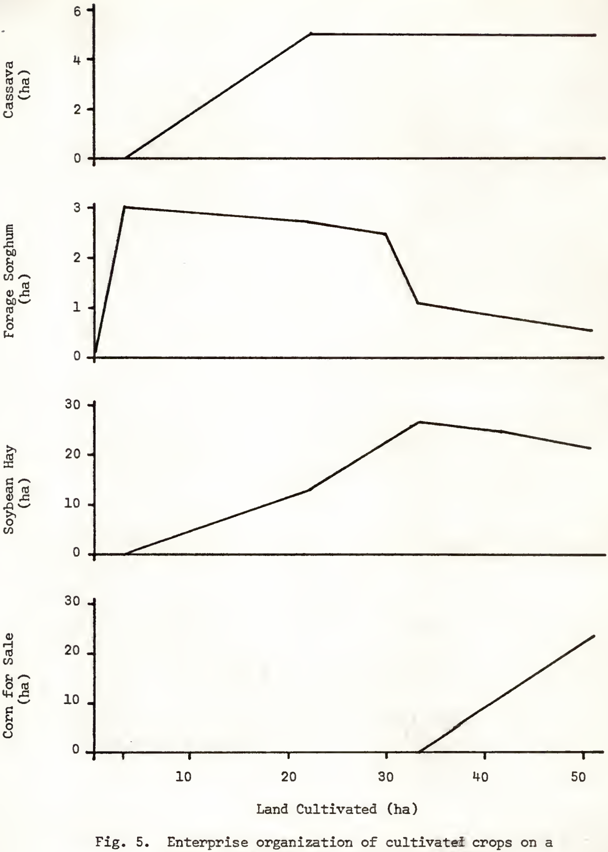

Fig. 5. Enterprise organization of cultivated crops on a 150-hectare farm for variable quantities of cultivated land.

for cows producing 4 and 6 liters of milk/cow/day. The values of interest are those in the last two columns of the table. They indicate the percentage change in the cost per unit that an activity would have to undergo in order to enter or leave the optimum solution. If the activity is already in the optimum solution, the value indicates the percentage that the cost per unit of that activity would have to increase before it would be replaced by another activity. On the other hand, if the activity is not presently in the optimum solution, the value indicates the percentage that the cost per unit of that activity would have to decrease before it would enter the solution replacing one of the existing activities. The percentage change in cost per unit could also represent a change in the yield of the activity. A higher yield than that which was assumed in this study would have the effect of lowering the cost per unit, while a lower yield would have the effect of increasing the cost per unit. Only those activities whose cost per unit would have to be changed by 50% or less to have an effect on the optimum solution are shown.

Several activities that appeared in the optimum feeding programs for the 4- and 6-liter cows are quite sensitive. Only a slight increase in the cost of producing a hectare of the particular activities would cause them to no longer be a part of the optimum feeding programs. The activities that were particularly sensitive are shown below with the percentage increases in unit cost that would cause them to no longer be a part of the two optimum feeding programs:

Activity	Feeding Program 4-liter cows %	 6-liter cows %
Make hay (two times during wet season)	2	3
Forage sorghum silage (feed Jan. 1-Apr. 30)	3	3
Forage sorghum silage (feed June 16-Aug. 31)	-	6
Produce soybean hay (feed Jan. 1-Apr. 30)	9	11
Produce soybean hay (feed June 16-Aug. 31)	9	7
Produce soybean hay (feed Sept. 1-Dec. 31)	8	10
Harvest cassava leaves (feed Sept. 1-Dec. 31)	-	3

Several activities that did not appear in the optimum feeding programs were also quite sensitive. Only a slight decrease in the cost of a unit of the particular activities would cause them to become a part of the optimum feeding programs. Those activities that were particularly sensitive are shown below with the percentage decreases in unit cost that would cause them to become a part of the two optimum feeding programs:

Activity	Feeding Program 4-liter cows %	 6-liter cows %
Make hay (one time during wet season)	6	6
Green chop during dry season	11	17

Activity	Feeding Program	
	4-liter cows	6-liter cows
	%	%
Make hay (one time during wet season) and green chop	8	13
Make hay (two times during wet season) and green chop	9	13
Forage sorghum silage (feed June 16-Aug. 31)	1	-
Make corn silage (feed Jan. 1-Apr. 30)	5	4
Make corn silage (feed June 16-Aug. 31)	11	8
Buy molasses (feed Sept. 1-Dec. 31)	16	3
Harvest cassava leaves (feed June 16-Aug. 31)	9	7
Produce cassava roots (feed Jan. 1-Apr. 30) and harvest cassava leaves (feed Sept. 1-Dec. 31)	19	4

Since many of the activities in the above lists use similar complements of machinery and equipment, changes in the unit cost of certain activities in either list would not greatly change the system. Hay making two times during the wet season could be easily replaced by hay making one time during the wet season, and making forage sorghum silage could be easily replaced by making corn silage or green chopping.

Fig. 6 shows the effect than an increase in the net return per hectare of corn sold would have on the enterprise organization of cultivated crops on a 150-ha farm. A limitation of 30 ha is placed

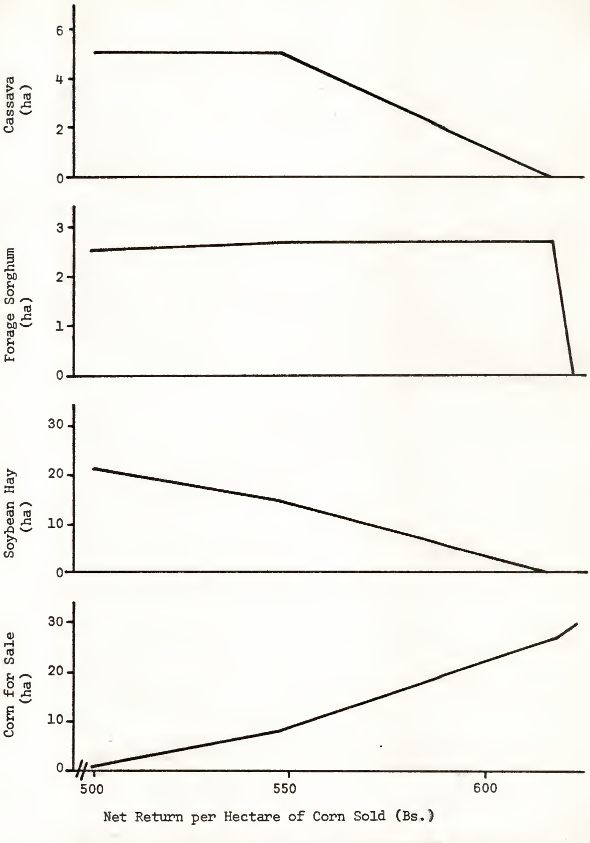

Fig. 6. Enterprise organization of cultivated crops on a 150-hectare farm associated with changes in the net return per hectare of corn sold.

on the land that can be put under cultivation. As stated previously in the methods section, an increase in net return per hectare could represent either an increase in the price of the product, an increase in yield, or a decrease in the variable costs associated with the production and sale of the crop. The net return from producing a hectare of corn for sale was 220 Bs. The yield that was associated with this net return was 2500 kg of grain per ha, the product price was 0.42 Bs. per kg and the variable costs were 830 Bs. per ha. The net return per hectare had to increase to 500 Bs. before it even entered the solution at a quantity of only 1 ha. A net return of approximately 525 Bs./ha would be needed before it would enter the solution at a level that would be considered practical. A net return of 525 Bs. would be equivalent to a 29% increase in the price of the corn activity assuming that the yield and variable costs remained the same. It would also be equivalent to a 29% increase in yield assuming that the product price and variable costs remained constant. The variable costs would have to decrease by 37% assuming no change in product price or yield in order to obtain this net return. The same analysis was run for the production of grain sorghum for sale and for the production of soybeans for sale. The relative changes in terms of product price, yield, or variable costs were very similar to those obtained for corn.

It can be seen in Fig. 6 that when the net return per ha of corn sold continues to rise above 500 Bs./ha, soybean hay is replaced by the production and sale of corn. Once it reaches 550 Bs., the production and sale of corn continues to replace more and more of the soybean hay in the system and also starts replacing cassava. Lastly it replaces the forage sorghum very rapidly as soon as the net return per hectare increases to 620 Bs. The grain sorghum and soybeans showed the same pattern as corn in the manner in which they substituted for the other crops in the system as their net return was increased.

Since the yield or product price increases are considerably large for cash crops of corn, grain sorghum, and soybeans to compete with the other activities in the use of farm resources, they do not appear to be profitable production alternatives in the study area.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A dairying region west of Lake Maracaibo, Venezuela, was chosen for this study. The area includes approximately 200,000 ha and is one of the principal dairying regions in the country. The majority of the pastures in the area is sown to guineagrass (Panicum maximum, Jacq.) with this grass forming the base of the ration for the cattle in the area.

Due to the long dry season, which usually begins in December and ends sometime in April, there is an uneven forage supply throughout the year. This requires that farmers use some form of supplementary feeding during parts of the year. This problem has been viewed with the cattle-forage-concentrate system in mind. The cattle alternatives included dairying and the purchase of beef bulls from other farmers in the area for further fattening. The forage alternatives included fertilization of the pastures with urea, hay making, silage making, deferred grazing, green chopping, and irrigation. The concentrate alternatives involved the purchase or production of various concentrate sources to be used in the system. Those concentrate sources which were considered for purchase were corn, grain sorghum, cassava roots, prepared concentrate, molasses, and a urea-molasses mix. Corn, grain sorghum, soybean hay, and cassava roots and leaves were the concentrate sources which were considered for production on the farm.

Aside from the possibility of animal production in this wet-dry tropical area, the feasibility of cash crops was also considered. The cash crops which were considered were corn, grain sorghum, soybeans, cassava roots, and guineagrass hay.

Objectives

The overall objective of this study was to evaluate potential farming systems in the study area. The study would also demonstrate the application of linear programming in developing farming systems for areas in the tropics which are similar to the one which was considered in this study.

The more immediate objectives were twofold: (1) to develop optimum enterprise organizations for three representative farm sizes in the area, (2) to establish priorities for future research in the region.

Optimum Enterprise Organizations

Enterprise organizations were developed for 12 distinct farming situations. The recommended optimum plan for a 150-ha farm simply involved the purchase and use of additional prepared concentrates so as to maintain the production of the cows which are presently on the farm at a level of 6 liters per cow per day. This results in a net income over a 10-year period of approximately 259,700 Bs. The system which was most commonly found on the farms of the area simply involved the use of prepared concentrates to maintain the production of the cows which are presently on the farm at a level of 4 liters per cow per day. This level of production, without the inclusion of any other improved practices, did not result in a net return on a 150-ha farm which was sufficient to cover the estimated minimum daily living expenses of the farmer and his family. Practically the same net income as is obtained in the optimum plan for cows producing 6 liters of milk per day could be obtained over a 10-year period with cows producing 4 liters of milk per day, but it would require that 20% of the farm be put under cultivation and that three times more capital be used. A much higher net return could be obtained with a 150-ha farm, with the production level of the cows maintained at 6 liters per day; but it required the use of much more capital than is assumed to be available or the alternative of placing 60% or more of the farm under cultivation. Limiting the forage conservation alternatives to hay making as opposed to hay making and silage making had a slight depression on net return over a 10-year period.

The net return on a 300-ha farm could be increased from 139,980 Bs. to 370,800 Bs. by simply maintaining the production of the cows at 6 liters per day instead of 4 liters per day. The net return could be further increased with the production level of the cows maintained at only 4 liters per day, but it required that 72 ha of the farm be put under cultivation and that 73 additional cows be purchased. This plan would require three times more capital than did the plan which simply involved increasing the production to 6 liters per day through the use of purchased concentrates.

The net return on a 450-ha farm could be increased from 225,600 Bs. to 581,000 Bs. over a 10-year period by simply maintaining the production of the cows at 6 liters instead of 4 liters per cow per day. This net return could be further increased with the production level of the cows maintained at only 4 liters per day, but it required that 103 ha of the farm be put under cultivation and that 141 additional cows be purchased. Here again, three times more capital would be required with this plan as opposed to the plan which simply involved maintaining the production of the cows at 6 liters of milk per day.

The effect that an increase in the land under cultivation would have on net return was determined for the 150-ha farm. The cows were assumed to be at a production level of 4 liters of milk per day and all forage and concentrate activities were allowed to enter the solution. It was found that the net return increased in a linear fashion until the area under cultivation reached approximately 30 ha at which time it started to level off with only very slight increases in net return thereafter. This analysis served as a basis for limiting the land under cultivation to 25% of the total farm land in the more intensive systems that were developed for each representative farm size.

Research Priorities

Certain activities consistently appeared in the more intensive farming systems. These are the activities that should probably be included in future experiments that are conducted in the area.

With regard to the cattle alternatives, dairying was much more profitable than fattening purchased bulls. As long as the cows were producing only 4 liters of milk per day, it was more profitable to market the bull calves produced on the farm at 2 1/2 years of age rather than sell them at 1 1/2 years of age. Once the production level was increased to 6 liters per cow per day, it became more profitable to sell the bull calves at 1 1/2 years of age. In all cases additional cows were needed to more fully utilize the feed that was being produced in the systems.

The forage alternatives that consistently appeared in the more intensive systems were fertilization of the pastures with urea, making hay two times during the season, and making forage sorghum silage.

The concentrate activities which consistently appeared were the production of soybeans to be used in the form of soybean hay, the use of cassava leaves after the roots had first been harvested for sale, the buying and feeding of molasses and a urea-molasses mix, and the production and purchase of corn to be used as a concentrate source.

The sale of fresh cassava roots and hay were the two cash crop activities which consistently appeared in the optimum farm plans.

A sensitivity analysis indicated that the activity of green chopping during the dry season would have been in the optimum solutions if its per unit cost had been decreased by only 11-17%. A decrease in the per unit costs of the activities that involved the combination of green chopping and hay making by only 8-13% would have allowed them to also come into the more intensive systems.

Although the activity of using cassava leaves as a concentrate source consistently appeared, the use of the roots did not. The per unit cost of the production of cassava roots to be fed in the January 1 to April 30 feeding period, followed by the harvest of the leaves for feeding during the September 1 to December 31 feeding period, would need to decrease by only 4 to 19%, however, in order for it to enter the optimum solution.

Conclusions

Linear programming was used to develop optimum enterprise organizations for the three representative farm sizes and to establish priorities for future research. As stated by Morley (16), however, "computers are extraordinarily efficient in doing only what they are told to do." The validity and usefulness of the results presented in this study are therefore very much dependent upon: (1) the applicability and appropriate specification of the selected alternatives, (2) the identification and appropriate specification of the limiting resources, and (3) the validity of the coefficients which were developed in terms of: (a) technical input-output relationships assumed, (b) prices assumed, and (c) technology assumed.

It will now be necessary to verify the results that are presented in this study through actual farming systems in the area in order to find out whether they are realistic and feasible. Now that the most profitable alternatives have been narrowed down to a smaller group, it will be much easier to obtain more detailed information on each one of them. An effort should be made to try to locate and solve the technological problems that will arise as the farmers proceed to implement these improved practices. A strong applied research and extension program is now needed in the area to follow through with this study. The farmers should be made aware of their adjustment potentials and the steps which they should take to improve production. Assistance should be given to them when they attempt to make the necessary changes.

Future research should be done with an eye to economic analyses. As was so appropriately stated by Morley (16), "we are dealing with biological activities that have economic objectives." Mott et al. (18) have stressed the importance of designing experiments that have relevance to a particular system. The experiment that was conducted by Mott et al. (19) to measure the contribution of pasture in pasture-grain feeding systems is a prime example of an experiment that was conducted in such a manner so that meaningful coefficients could be obtained for a particular system. Experiments of this type are urgently needed in this region west of Lake Maracaibo, Venezuela. The output per animal and the output per hectare should be obtained for each of the cattle-forage feeding systems that are recommended in this study. Efforts should be made to record all inputs and requirements that go into a particular activity in order to obtain a certain level of production.

Specific Recommendations

As was stated earlier, the optimum plans that were generated in this study are not directly applicable to any one farming situation in the area. All of these plans will need to be adjusted to the set of restrictive resources that is on a particular farm so that they give results that apply to that particular set of circumstances. The Programmed Budgeting technique developed by Huffman (9) could be very useful at this point. This technique would standardize the data that have already been gathered for this study so that they could be applied to any farm situation in the area without having to be rerun on the computer each time.

This study had a shortcoming in that it was developed for only one year - that year being the adjustment year. It would be interesting to subject this study to dynamic linear programming and thus introduce the factor of time. An attempt was made to estimate the net return over a 10-year period, but this is only a rough approximation. To know what would have been the annual adjustment strategies over a long time period, however, dynamic linear programming should be used.

The results from this study suggest several areas in which experiments are badly needed. This study indicated that it would be highly profitable for the farmers of the area to put up to 25% of their farms under cultivation. What it did not evaluate, however, was the kind of crop rotation that they should follow in doing so. A study of various crop rotation systems with the animal in the system would be warranted. Information is needed on just how many years out of ten farmers will be able to have a certain piece of land under cultivation.

Another area in which further research is indicated is that of hay making. This study indicated that hay making is profitable, but the method in which it should be done is not well known at this time. There is some evidence that the conventional baler is too complicated at the present time for producers in the area. Other simpler methods should be investigated with the aim of finding a system that will be readily accepted by the farmers in the area.

The alternative of making forage sorghum silage warrants further testing. Although this alternative is presently used in the area on a limited scale, the testing of improved varieties of forage sorghum and the investigation of better methods of preservation are still needed.

Very little information is available on the alternative of producing soybeans to be used in the system as soybean hay. Although soybeans were used in this study, the results indicate that a crop is needed in the system that is a good source of both energy and protein. Some tropical legume might satisfy these requirements and at the same time be much better adapted to the area. Other cultivated crops which would merit further testing are corn and cassava. Experiments should be conducted to test new varieties under various fertilizer and management schemes. All of these crops should be tested in plots that are large enough to use mechanized machinery as this is the manner in which they will probably be cultivated in the future. Special attention should be given to the development of better methods for harvesting cassava leaves which this study indicated would be a good protein source.

The cattle-forage-concentrate systems that are recommended in this study should be tested on a small scale. It would be particularly important to test the concentrate sources such as soybean hay, cassava leaves, molasses, and the urea-molasses mix in combination with the forage alternatives that are recommended for the more intensive systems.

Hopefully the results from this study combined with the results from the above experiments will have a beneficial effect in the further development of the area.

APPENDIX

Table 6. The linear programming matrix for feeding program cost minimization.

Row No.	Description	Unit	Maintain Pastures 1 ha	Fertilize Pastures 2 ha	Irrigate Pastures 3 ha	Fertilize and Irrigate 4 ha	Make Hay (one time) 5 ha	Fertilize and Make Hay (one time) 6 ha
1	Cost	Bs.	94.00	402.00	671.00	883.00	400.20	636.20
	Energy							
2	Jan. 1-Apr. 30	TDN,kg	425	775	1,531	1,531	425	775
3	May 1-June 15	TDN,kg	400	1,150	400	1,150	400	1,150
4	June 16-Aug. 31	TDN,kg	400	1,000	1,310	1,310	400	1,000
5	Sept. 1-Dec. 31	TDN,kg	775	2,075	775	2,075	489	1,310
	Protein							
6	Jan. 1-Apr. 30	CP,kg	42	139	342	342	42	139
7	May 1-June 15	CP,kg	72	299	72	299	72	299
8	June 16-Aug. 31	CP,kg	64	220	288	288	64	220
9	Sept. 1-Dec. 31	CP,kg	124	456	124	456	78	288
	Dry matter							
10	Jan. 1-Apr. 30	DM,kg	944	1,722	3,156	3,156	944	1,722
11	May 1-June 15	DM,kg	800	2,300	800	2,300	800	2,300
12	June 16-Aug. 31	DM,kg	800	2,000	2,620	2,620	800	2,000
13	Sept. 1-Dec. 31	DM,kg	1,550	4,150	1,550 ?	4,150	978	2,620
	CP from urea		4000	1000		1000		
14	Jan. 1-Apr. 30	CP,kg						
15	May 1-June 15	CP,kg						
16	June 16-Aug. 31	CP,kg						
17	Sept. 1-Dec. 31	CP,kg						
18	TDN from hay	kg					-2,250	-2,250
19	CP from hay	kg					-360	-360
20	TDN from silage	kg						
21	CP from silage	kg						

Table 6. (Continued)

Row		Irrigate and Make Hay (one time)	Fertilize Irrigate and Make Hay (one time)	Make Hay (two times)	Fertilize and Make Hay (two times)	Irrigate and Make Hay (two times)	Make Silage (one time)	Fertilize and Make Silage (one time)
		7	8	9	10	11	12	13
No.	Description	ha	ha	ha	ha	ha	ha	ha
1	Cost	977.20	1,087.20	671.40	835.40	1,248.40	464.20	700.20
	Energy							
2	Jan. 1-Apr. 30	1,531	1,531	425	775	1,531	425	775
3	May 1-June 15	400	1,150	400	1,150	400	400	1,150
4	June 16-Aug. 31	1,310	1,310	400	1,000	1,310	400	1,000
5	Sept. 1-Dec. 31	589	1,310	203	545	203	489	1,310
	Protein							
6	Jan. 1-Apr. 30	342	342	42	139	342	42	139
7	May 1-June 15	72	299	72	299	72	72	299
8	June 16-Aug. 31	288	288	64	220	288	64	220
9	Sept. 1-Dec. 31	78	288	32	119	32	78	288
	Dry matter							
10	Jan. 1-Apr. 30	3,156	3,156	944	1,722	3,156	944	1,722
11	May 1-June 15	800	2,300	800	2,300	800	800	2,300
12	June 16-Aug. 31	2,620	2,620	800	2,000	2,620	800	2,000
13	Sept. 1-Dec. 31	978	2,620	406	1,090	406	978	2,620
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay	-2,250	-2,250	-4,500	-4,500	-4,500		
19	CP from hay	-360	-360	-720	-720	-720		
20	TDN from silage						-2,415	-2,415
21	CP from silage						-360	-360

Table 6. (Continued)

Row No.	Description	Irrigate and Make Silage (one time)	Fertilize Irrigate and Make Silage (one time)	Make Silage (two times)	Fertilize and Make Silage (two times)	Irrigate and Make Silage (two times)	Green Chop During Dry Season	Fertilize and Green Chop
		14	15	16	17	18	19	20
		ha	ha	ha	ha	ha	ha	ha
1	Cost	1,041.20	1,161.20	799.40	963.40	1,376.40	1,402.00	1,690.00
	Energy							
2	Jan. 1-Apr. 30	1,531	1,531	425	775	1,531	5,000	5,000
3	May 1-June 15	400	1,150	400	1,150	400	400	1,150
4	June 16-Aug. 31	1,310	1,310	400	1,000	1,310	2,666	2,916
5	Sept. 1-Dec. 31	589	1,310	203	545	203	775	2,075
	Protein							
6	Jan. 1-Apr. 30	342	342	42	139	342	800	800
7	May 1-June 15	72	299	72	299	72	72	299
8	June 16-Aug. 31	288	288	64	220	288	427	491
9	Sept. 1-Dec. 31	78	288	32	119	32	124	456
	Dry matter							
10	Jan. 1-Apr. 30	3,156	3,156	944	1,722	3,156	10,000	10,000
11	May 1-June 15	800	2,300	800	2,300	800	800	2,300
12	June 16-Aug. 31	2,620	2,620	800	2,000	2,620	5,332	5,832
13	Sept. 1-Dec. 31	978	2,620	406	1,090	406	1,550	4,150
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage	-2,415	-2,415	-4,830	-4,830	-4,830		
21	CP from silage	-360	-360	-720	-720	-720		

Table 6. (Continued)

Row No.	Description	Make Hay (one time) and Green Chop	Fertilize Make Hay (one time) and Green Chop	Make Hay (two times) and Green Chop	Make Silage (one time) and Green Chop	Fertilize Make Silage (two times) and Green Chop	Make Silage (two times) and Green Chop	Deferred Graze
		21	22	23	24	25	26	27
		ha	ha	ha	ha	ha	ha	ha
1	Cost	1,673.20	1,913.20	2,001.40	1,722.20	1,962.20	2,129.40	225.00
	Energy							
2	Jan. 1-Apr. 30	5,000	5,000	5,000	5,000	5,000	5,000	1,038
3	May 1-June 15	400	1,150	400	400	1,150	400	400
4	June 16-Aug. 31	2,666	2,916	2,666	2,666	2,916	2,666	400
5	Sept. 1-Dec. 31	589	1,310	203	489	1,310	203	387
	Protein							
6	Jan. 1-Apr. 30	800	800	800	800	800	800	146
7	May 1-June 15	72	299	72	72	299	72	72
8	June 16-Aug. 31	427	491	427	427	491	427	64
9	Sept. 1-Dec. 31	78	288	32	78	288	32	62
	Dry matter							
10	Jan. 1-Apr. 30	10,000	10,000	10,000	10,000	10,000	10,000	2,306
11	May 1-June 15	800	2,300	800	800	2,300	800	800
12	June 16-Aug. 31	5,332	5,832	5,332	5,332	5,832	5,332	800
13	Sept. 1-Dec. 31	978	2,620	406	978	2,620	406	774
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay	-2,250	-2,250	-4,500				
19	CP from hay	-360	-360	-720				
20	TDN from silage				-2,415	-2,415	-4,830	
21	CP from silage				-360	-360	-720	

Table 6. (Continued)

Row No.	Description	Fertilize and Deferred Graze 28 ha	Make Hay (one time) and Deferred Graze 29 ha	Fertilize Make Hay (one time) and Deferred Graze 30 ha	Make Silage (one time) and Deferred Graze 31 ha	Fertilize Make Silage (one time) and Deferred Graze 32 ha	Fertilize and Make Silage (one time and custom hired) 33 ha	Fertilize and Make Silage (two times and custom hired) 34 ha
1	Cost	417.00	496.20	636.20	560.20	700.20	946.20	1,455.40
	Energy							
2	Jan. 1-Apr. 30	1,038	1,038	1,038	1,038	1,038	775	775
3	May 1-June 15	1,150	400	1,150	400	1,150	1,150	1,150
4	June 16-Aug. 31	1,000	400	1,000	400	1,000	1,000	1,000
5	Sept. 1-Dec. 31	1,037	101	272	101	272	1,310	545
	Protein							
6	Jan. 1-Apr. 30	146	146	146	146	146	139	139
7	May 1-June 15	299	72	299	72	299	299	299
8	June 16-Aug. 31	220	64	220	64	220	220	220
9	Sept. 1-Dec. 31	228	16	66	16	66	288	119
	Dry matter							
10	Jan. 1-Apr. 30	2,306	2,306	2,306	2,306	2,306	1,722	1,722
11	May 1-June 15	2,300	800	2,300	800	2,300	2,300	2,300
12	June 16-Aug. 31	2,000	800	2,000	800	2,000	2,000	2,000
13	Sept. 1-Dec. 31	2,074	202	544	202	544	2,620	1,090
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay		-2,250	-2,250				
19	CP from hay		-360	-360				
20	TDN from silage				-2,415	-2,415	-2,415	-4,830
21	CP from silage				-360	-360	-360	-720

Table 6. (Continued)

Row No.	Description	Fertilize Make Silage (one time and custom hired) and Deferred Graze 35 ha	Green Chop During Entire Year 36 ha	Green Chop using Forage Sorghum 37 ha	Make Silage using Forage Sorghum Fed Jan. 1-Apr. 30 38 ha	Make Silage using Forage Sorghum Fed June 16-Aug. 31 39 ha	Make Silage (custom hired) using Forage Sorghum Fed Jan. 1-Apr. 30 40 ha	Make Silage Using Corn Fed Jan. 1-Apr. 30 41 ha
1	Cost	946.20	2,729.00	2,566.75	1,701.85	1,701.85	2,562.85	1,051.20
	Energy							
2	Jan. 1-Apr. 30	1,038	5,000	10,325	9,723		9,723	6,300
3	May 1-June 15	1,150	2,500	4,425				
4	June 16-Aug. 31	1,000	4,275	2,950		9,723		
5	Sept. 1-Dec. 31	272	6,800					
	Protein							
6	Jan. 1-Apr. 30	146	800	1,785	1,607		1,607	729
7	May 1-June 15	299	409	765				
8	June 16-Aug. 31	220	684	510		1,607		
9	Sept. 1-Dec. 31	66	1,084					
	Dry matter							
10	Jan. 1-Apr. 30	2,306	10,000	17,500	16,480		16,480	10,000
11	May 1-June 15	2,300	5,000	7,500				
12	June 16-Aug. 31	2,000	8,550	5,000		16,480		
13	Sept. 1-Dec. 31	544	13,600					
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage	-2,415						
21	CP from silage	-360						

Table 6. (Continued)

Row No.	Description	Make Silage Using Corn Fed June 16-Aug. 31 42 ha	Feed Hay Jan. 1-Apr. 30 43 ton	Feed Hay June 16-Aug. 31 44 ton	Feed Silage Jan. 1-Apr. 30 45 ton	Feed Silage June 160Aug. 31 46 ton	Produce Corn To Be Fed Jan. 1-Apr. 30 47 ha	Produce Corn To Be Fed May 1-June 15 48 ha
1	Cost	1,051.20	4.45	4.45	4.20	4.20	893.00	908.00
	Energy							
2	Jan. 1-Apr. 30		500		134		2,550	
3	May 1-June 15							2,550
4	June 16-Aug. 31	6,300		500		134		
5	Sept. 1-Dec. 31							
	Protein							
6	Jan. 1-Apr. 30		80		20		279	
7	May 1-June 15							279
8	June 16-Aug. 31	729		80		20		
9	Sept. 1-Dec. 31							
	Dry matter							
10	Jan. 1-Apr. 30		1,000		268		3,000	
11	May 1-June 15							3,000
12	June 16-Aug. 31	10,000		1,000		268		
13	Sept. 1-Dec. 31							
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay		500	500				
19	CP from hay		80	80				
20	TDN from silage				134	134		
21	CP from silage				20	20		

Table 6. (Continued)

Row No.	Description	Produce Corn To Be Fed June 16-Aug. 31	Produce Corn To Be Fed Sept. 1-Dec. 31	Produce Sorghum To Be Fed Jan. 1-Apr. 30	Produce Sorghum To Be Fed May 1-June 15	Produce Sorghum To Be Fed June 16-Aug. 31	Produce Sorghum To Be Fed Sept. 1-Dec. 31	Produce Soybeans To Be Fed Jan. 1-Apr. 30
		49	50	51	52	53	54	55
		ha	ha	ha	ha	ha	ha	ha
1	Cost	923.00	938.00	924.00	942.75	961.50	980.25	674.25
	Energy							
2	Jan. 1-Apr. 30			2,888				3,120
3	May 1-June 15				2,888			
4	June 16-Aug. 31	2,550				2,888		
5	Sept. 1-Dec. 31		2,550				2,888	
	Protein							
6	Jan. 1-Apr. 30			442				978
7	May 1-June 15				442			
8	June 16-Aug. 31	279				442		
9	Sept. 1-Dec. 31		279				442	
	Dry matter							
10	Jan. 1-Apr. 30			3,750				6,000
11	May 1-June 15				3,750			
12	June 16-Aug. 31	3,000				3,750		
13	Sept. 1-Dec. 31		3,000				3,750	
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6. (Continued)

Row No.	Description	Produce Soybeans To Be Fed May 1-June 15 56 ha	Produce Soybeans To Be Fed June 16-Aug. 31 57 ha	Produce Soybeans To Be Fed Sept. 1-Dec. 31 58 ha	Buy Corn To Be Fed Jan. 1-Apr. 30 59 ton	Buy Corn To Be Fed May 1-June 15 60 ton	Buy Corn To Be Fed June 16-Aug. 31 61 ton	Buy Corn To Be Fed Sept. 1-Dec. 31 62 ton
1	Cost	704.25	734.25	764.25	480.00	485.00	490.00	495.00
	Energy							
2	Jan. 1-Apr. 30				810			
3	May 1-June 15	3,120				810		
4	June 16-Aug. 31		3,120				810	
5	Sept. 1-Dec. 31			3,120				810
	Protein							
6	Jan. 1-Apr. 30				89			
7	May 1-June 15	978				89		
8	June 16-Aug. 31		978				89	
9	Sept. 1-Dec. 31			978				89
	Dry matter							
10	Jan. 1-Apr. 30				1,000			
11	May 1-June 15	6,000				1,000		
12	June 16-Aug. 31		6,000				1,000	
13	Sept. 1-Dec. 31			6,000				1,000
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6. (Continued)

Row No.	Description	Buy Sorghum To Be Fed Jan. 1-Apr. 30	Buy Sorghum To Be Fed May 1-June 15	Buy Sorghum To Be Fed June 16-Aug. 31	Buy Sorghum To Be Fed Sept. 1-Dec. 31	Buy Cassava To Be Fed Jan. 1-Apr. 30	Buy Cassava To Be Fed May 1-June 15	Buy Cassava To Be Fed June 16-Aug. 31
		63	64	65	66	67	68	69
		ton	ton	ton	ton	ton	ton	ton
1	Cost	385.00	390.00	395.00	400.00	155.00	155.00	155.00
	Energy							
2	Jan. 1-Apr. 30	740				257		
3	May 1-June 15		740				257	
4	June 16-Aug. 31			740				257
5	Sept. 1-Dec. 31				740			
	Protein							
6	Jan. 1-Apr. 30	111				11		
7	May 1-June 15		111				11	
8	June 16-Aug. 31			111				11
9	Sept. 1-Dec. 31				111			
	Dry matter							
10	Jan. 1-Apr. 30	1,000				1,000		
11	May 1-June 15		1,000				1,000	
12	June 16-Aug. 31			1,000				1,000
13	Sept. 1-Dec. 31				1,000			
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6. (Continued)

Row No.	Description	Buy Cassava To Be Fed Sept. 1-Dec. 31 70 ton	Buy Concentrate To Be Fed Jan. 1-Apr. 30 71 ton	Buy Concentrate To Be Fed May 1-June 15 72 ton	Buy Concentrate To Be Fed June 16-Aug. 31 73 ton	Buy Concentrate To Be Fed Sept. 1-Dec. 31 74 ton	Buy Molasses To Be Fed Jan. 1-Apr. 30 75 ton	Buy Molasses To Be Fed May 1-June 15 76 ton
1	Cost	155.00	490.00	490.00	490.00	490.00	200.00	200.00
	Energy							
2	Jan. 1-Apr. 30		600				683	
3	May 1-June 15			600				683
4	June 16-Aug. 31				600			
5	Sept. 1-Dec. 31	257				600		
	Protein							
6	Jan. 1-Apr. 30		200					
7	May 1-June 15			200				
8	June 16-Aug. 31				200			
9	Sept. 1-Dec. 31	11				200		
	Dry matter							
10	Jan. 1-Apr. 30		1,000				1,000	
11	May 1-June 15	1,000		1,000				
12	June 16-Aug. 31				1,000			
13	Sept. 1-Dec. 31	1,000				1,000		
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6. (Continued)

Row No.	Description	Buy Molasses To Be Fed June 16-Aug. 31	Buy Molasses To Be Fed Sept. 1-Dec. 31	Buy Urea-Molasses To Be Fed Jan. 1-Apr. 30	Buy Urea-Molasses To Be Fed May 1-June 15	Buy Urea-Molasses To Be Fed June 16-Aug. 31	Buy Urea-Molasses To Be Fed Sept. 1-Dec. 31	Produce cassava and Harvest Leaves fed Jan. 1-Apr. 30
		77	78	79	80	81	82	83
		ton	ton	ton	ton	ton	ton	ha.
1	Cost	200.00	200.00	250.00	250.00	250.00	250.00	1,758.80
	Energy							
2	Jan. 1-Apr. 30			615				5,955
3	May 1-June 15				615			
4	June 16-Aug. 31	683				615		
5	Sept. 1-Dec. 31		683				615	
	Protein							
6	Jan. 1-Apr. 30			262				915
7	May 1-June 15				262			
8	June 16-Aug. 31					262		
9	Sept. 1-Dec. 31						262	
	Dry matter							
10	Jan. 1-Apr. 30			1,000				8,250
11	May 1-June 15				1,000			
12	June 16-Aug. 31	1,000				1,000		
13	Sept. 1-Dec. 31		1,000				1,000	
	CP from urea							
14	Jan. 1-Apr. 30			262				
15	May 1-June 15				262			
16	June 16-Aug. 31					262		
17	Sept. 1-Dec. 31						262	
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6 (Continued)

Row No.	Description	Produce Cassava and Harvest leaves fed May 1-June 15 84 ha	Produce Cassava and Harvest leaves fed June 16-Aug. 31 85 ha	Produce Cassava and Harvest leaves fed Sept. 1-Dec. 31 86 ha	Harvest leaves of Cassava fed Jan. 1-Apr. 30 87 ha	Harvest leaves of Cassava fed May 1-June 15 88 ha	Harvest leaves of Cassava fed June 16-Aug. 31 89 ha	Harvest leaves of Cassava fed Sept. 1-Dec. 31 90 ha
1	Cost	1,773.80	1,788.80	1,803.80	558.30	573.30	588.30	603.30
	Energy							
2	Jan. 1-Apr.30				2,100			
3	May 1-June 15	5,955				2,100		
4	June 16-Aug. 31		5,955				2,100	
5	Sept. 1-Dec. 31			5,955				2,100
	Protein							
6	Jan. 1-Apr. 30				750			
7	May 1-June 15	915				750		
8	June 16-Aug. 31		915				750	
9	Sept. 1-Dec. 31			915				750
	Dry matter							
10	Jan. 1-Apr. 30				3,000			
11	May 1-June 15	8,250				3,000		
12	June 16-Aug. 31		8,250				3,000	
13	Sept. 1-Dec. 31			8,250				3,000
	CP from urea							
14	Jan. 1-Apr. 30							
15	May 1-June 15							
16	June 16-Aug. 31							
17	Sept. 1-Dec. 31							
18	TDN from hay							
19	CP from hay							
20	TDN from silage							
21	CP from silage							

Table 6. (Continued)

Row No.	Description		Right Hand Side Fatten Bulls Buy in Jan. Sell in July 91 Head	Right Hand Side Fatten Bulls Buy in Jan. Sell in Dec. 92 Head	Right Hand Side Milk Cows Prod. 6 Liters Fatten Calves 93 Cow	Right Hand Side Milk Cows Prod. 6 Liters Sell Calves 94 Cow	Right Hand Side Milk Cows Prod. 4 Liters Fatten Calves 95 Cow	Right Hand Side Milk Cows Prod. 4 Liters Sell Calves 96 Cow
1	Cost							
	Energy							
2	Jan. 1-Apr. 30	≥	444.0	348.0	1,305.6	1,162.6	1,230.0	1,087.0
3	May 1-June 15	≥	239.0	207.0	521.0	448.0	492.0	419.0
4	June 16-Aug. 31	≥	78.0	400.0	925.5	785.5	877.0	747.0
5	Sept. 1-Dec. 31	≥	0	744.0	1,597.9	1,369.9	1,521.0	1,293.0
	Protein							
6	Jan. 1-Apr. 30	≥	79.0	58.0	230.5	208.5	213.0	191.0
7	May 1-June 15	≥	39.0	36.0	104.7	91.7	98.0	85.0
8	June 16-Aug. 31	≥	13.0	69.0	167.2	145.2	156.0	134.0
9	Sept. 1-Dec. 31	≥	0	107.0	285.8	249.8	268.0	232.0
	Dry matter							
10	Jan. 1-Apr. 30	≤	750.0	705.0	2,460.0	2,174.0	2,460.0	2,174.0
11	May 1-June 15	≤	345.0	307.0	984.0	838.0	984.0	838.0
12	June 16-Aug. 31	≤	116.6	604.4	1,754.0	1,494.0	1,754.0	1,494.0
13	Sept. 1-Dec. 31	≤	0	1,183.4	3,042.0	2,586.0	3,042.0	2,586.0
	CP from urea							
14	Jan. 1-Apr. 30	≤	26.3	19.3	76.8	69.5	71.0	63.7
15	May 1-June 15	≤	13.0	12.0	34.9	30.6	32.7	28.3
16	June 16-Aug. 31	≤	4.3	23.0	55.8	48.4	52.0	44.7
17	Sept. 1-Dec. 31	≤	0	35.7	95.3	83.3	89.3	77.3
18	TDN from hay	≤	0	0	0	0	0	0
19	CP from hay	≤	0	0	0	0	0	0
20	TDN from silage	≤	0	0	0	0	0	0
21	CP from silage	≤	0	0	0	0	0	0

Table 7. Minimum cost feeding programs for dairy cows producing 4 liters per day; bull calves sold at 1 1/2 years of age.

Description	Unit	All Alternatives Considered 1	Silage Alternatives Prohibited 2	Concentrate Producing Alternatives Prohibited 3	Concentrate Producing and Silage Alternatives Prohibited 4
Net return less feed cost	Bs.	804.17	804.17	804.17	804.17
Feeding program					
Maintain pasture	ha	.632	.572	.445	.444
Fertilize pasture	ha	.104	.104	.210	.146
Make hay (two times)	ha	.116	.176		.185
Feed Jan. 1-Apr. 30	ton	.467	1.007		1.008
Feed June 16-Aug. 31	ton	.580	.580		.656
Forage sorghum silage	ha	.024		.104	
Feed Jan. 1-Apr. 30	ton	1.691		4.698	
Feed June 16-Aug. 31	ton			2.588	
Soybean hay	ha	.268	.220		
Feed Jan. 1-Apr. 30	ton	.423	.067		
Feed June 16-Aug. 31	ton	.103	.103		
Feed Sept. 1-Dec. 31	ton	1.084	1.150		
Harvest cassava leaves	ha		.072		
Feed Jan. 1-Apr. 30	ton		.215		
Buy prepared concentrate	ton			.020	.136
Feed Sept. 1-Dec. 31	ton			.020	.136
Buy molasses	ton			.469	.584
Feed Jan. 1-Apr. 30	ton			.135	.243
Feed June 16-Aug. 31	ton				.035
Feed Sept. 1-Dec. 31	ton			.295	.295
Feeding program cost	Bs.	422.91	427.59	512.20	559.00
Net return	Bs.	381.26	376.58	291.97	245.17
Annual capital used	Bs.	281.85	219.48	599.40	269.37
Total land used	ha	1.144	1.072	.759	.775
Land in cultivated crops	ha	.292	.220	.104	0

Table 8. Minimum cost feeding programs for dairy cows producing 4 liters per day; bull calves marketed at 2 1/2 years of age.

Description	Unit	All Alternatives Considered 5	Silage Alternatives Prohibited 6	Concentrate Producing Alternatives Prohibited 7	Concentrate Producing and Silage Alternatives Prohibited 8
Net return less feed cost	Bs.	903.49	903.49	903.49	903.49
Feeding program					
Maintain pasture	ha	.810	.737	.585	.543
Fertilize pasture	ha	.103	.103	.224	.167
Make hay (two times)	ha	.125	.198		.208
Feed Jan. 1-Apr. 30	ton	.446	1.102		1.091
Feed June 16-Aug. 31	ton	.677	.677		.777
Forage sorghum silage	ha	.029		.117	
Feed Jan. 1-Apr. 30	ton	2.057		5.158	
Feed June 16-Aug. 31	ton			3.014	
Soybean hay	ha	.308	.249		
Feed Jan. 1-Apr. 30	ton	.469	.037		
Feed June 16-Aug. 31	ton	.119	.119		
Feed Sept. 1-Dec. 31	ton	1.259	1.340		
Harvest cassava leaves	ha		.087		
Feed Jan. 1-Apr. 30	ton		.261		
Buy prepared concentrate	ton			.019	.143
Feed Sept. 1-Dec. 31	ton			.019	.143
Buy molasses	ton			.558	.712
Feed Jan. 1-Apr. 30	ton				.102
Feed Sept. 1-Dec. 31	ton			.558	.610
Buy urea-molasses mix	ton			.489	.647
Feed Jan. 1-Apr. 30	ton			.148	.271
Feed June 16-Aug. 31	ton				.035
Feed Sept. 1-Dec. 31	ton			.341	.341
Feeding program cost	Bs.	483.44	489.13	585.02	639.98
Net return	Bs.	420.05	414.36	318.47	263.51
Annual capital used	Bs.	330.20	254.33	677.10	309.53
Total land used	ha	1.375	1.287	.926	.917
Land in cultivated crops	ha	.337	.249	.117	0

Table 9. Minimum cost feeding programs for dairy cows producing 6 liters per day; bull calves sold at 1 1/2 years of age.

Description	Unit	All Alternatives Considered 9	Silage Alternatives Prohibited 10	Concentrate Producing Alternatives Prohibited 11	Concentrate Producing and Silage Alternatives Prohibited 12
Net return less feed cost	Bs.	1208.09	1208.09	1208.09	1208.09
Feeding program					
Maintain pasture	ha	.870	.741	.109	
Fertilize pasture	ha			.286	.265
Make hay (two times)	ha	.019	.148		.168
Feed Jan. 1-Apr. 30	ton		.746		.935
Feed June 16-Aug. 31	ton	.175	.590		.576
Forage sorghum silage	ha	.078		.132	
Feed Jan. 1-Apr. 30	ton	3.858		5.991	
Feed June 16-Aug. 31	ton	1.600		3.284	
Soybean hay	ha	.240	.184		
Feed Jan. 1-Apr. 30	ton	.274			
Feed June 16-Aug. 31	ton	.230			
Feed Sept. 1-Dec. 31	ton	.939	1.103		
Produce corn	ha	.008	.008		
Feed May 1-June 15	ton	.025	.025		
Harvest cassava leaves	ha	.181	.385		
Feed Jan. 1-Apr. 30	ton	.152	.588		
Feed May 1-June 15	ton	.101	.101		
Feed June 16-Aug. 31	ton		.193		
Feed Sept. 1-Dec. 31	ton	.290	.274		
Buy corn	ton			.093	.093
Feed May 1-June 15	ton			.093	.093
Buy grain sorghum	ton				.182
Feed Jan. 1-Apr. 30	ton				.182
Buy prepared concentrate	ton			.113	.201
Feed Sept. 1-Dec. 31	ton			.113	.201
Buy molasses	ton			.628	1.000
Feed Jan. 1-Apr. 30	ton				.175
Feed June 16-Aug. 31	ton				.138
Feed Sept. 1-Dec. 31	ton			.628	.687
Buy urea-molasses mix	ton			.420	.698
Feed Jan. 1-Apr. 30	ton			.102	.265
Feed June 16-Aug. 31	ton				.115
Feed Sept. 1-Dec. 31	ton			.318	.318

Table 9. (Continued)

Description	Unit	All Alternatives Considered 9	Silage Alternatives Prohibited 10	Concentrate Producing Alternatives Prohibited 11	Concentrate Producing and Silage Alternatives Prohibited 12
Feeding program cost	Bs.	519.05	544.90	679.68	814.76
Net return	Bs.	689.04	663.19	528.41	393.33
Annual capital used	Bs.	572.62	372.18	777.00	455.17
Total land used	ha	1.215	1.081	.527	.433
Land in cultivated crops	ha	.326	.192	.132	0

Table 10. Minimum cost feeding programs for dairy cows producing 6 liters per day; bull calves marketed at 2 1/2 years of age.

Description	Unit	All Alternatives Considered 13	Silage Alternatives Prohibited 14	Concentrate Producing Alternatives Prohibited 15	Concentrate Producing and Silage Alternatives Prohibited 16
Net return less feed cost	Bs.	1305.20	1305.20	1305.20	1305.20
Feeding program					
Maintain pasture	ha	1.052		.327	
Fertilize pasture	ha		.313	.273	.321
Make hay (one time)	ha		.226		
Make hay (two times)	ha	.021			.189
Feed Jan. 1-Apr. 30	ton		.590		1.053
Feed June 16-Aug. 31	ton	.185	.426		.649
Forage sorghum silage					
Feed Jan. 1-Apr. 30	ton	4.166	4.095	6.294	
Feed June 16-Aug. 31	ton	2.081	2.040	3.753	
Soybean hay	ha	.277	.214		
Feed Jan. 1-Apr. 30	ton	.307	.023		
Feed June 16-Aug. 31	ton	.221			
Feed Sept. 1-Dec. 31	ton	1.132	1.263		
Produce corn	ha	.008	.028		
Feed May 1-June 15	ton	.025	.083		
Corn silage	ha		.004		
Feed June 16-Aug. 31	ton		.163		
Harvest cassava leaves	ha	.177	.129		
Feed Jan. 1-Apr. 30	ton	.159	.130		
Feed May 1-June 15	ton	.101			
Feed Sept. 1-Dec. 31	ton	.271	.258		
Buy corn	ton				.093
Feed May 1-June 15	ton				.093
Buy grain sorghum	ton				.152
Feed Jan. 1-Apr. 30	ton				.152
Buy prepared concentrate	ton			.127	.190
Feed Sept. 1-Dec. 31	ton			.127	.190
Buy molasses	ton			.699	1.230
Feed Jan. 1-Apr. 30	ton				.230
Feed June 16-Aug. 31	ton				.187
Feed Sept. 1-Dec. 31	ton			.699	.813

Table 10. (Continued)

Description	Unit	All Alternatives Considered 13	Silage Alternatives Prohibited 14	Concentrate Producing Alternatives Prohibited 15	Concentrate Producing and Silage Alternatives Prohibited 16
Buy urea-molasses mix	ton			.495	.781
Feed Jan. 1-Apr. 30	ton			.131	.293
Feed June 16-Aug. 31	ton				.124
Feed Sept. 1-Dec. 31	ton			.364	.364
Feeding program cost	Bs.	580.52	637.28	753.12	901.57
Net return	Bs.	724.68	667.92	552.08	403.63
Annual capital used	Bs.	640.78	629.44	851.86	496.24
Total land used	ha	1.447	.873	.744	.510
Land in cultivated crops	ha	.374	.334	.144	0

Table 11. Minimum cost feeding programs for dairy cows producing 4 and 6 liters per day; fattening of purchased bulls; farm produced bull calves marketed at 2 1/2 years of age; all forage and concentrate alternatives considered.

Description	Unit	4-Liter Cows Fatten Purchased Bulls 6 Months 17	4-Liter Cows Fatten Purchased Bulls 12 Months 18	6-Liter Cows Fatten Purchased Bulls 6 Months 19	6-Liter Cows Fatten Purchased Bulls 12 Months 20
Net return less feed cost	Bs.	1092.18	1240.55	1493.89	1642.26
Feeding program					
Maintain pasture	ha	1.322	1.285	1.241	1.233
Fertilize pasture	ha				
Make hay (two times)	ha	.045	.079		.005
Feed Jan. 1-Apr. 30	ton		.701		.045
Feed June 16-Aug. 31	ton	.405	.011		
Forage sorghum silage	ha	.087	.095	.134	.145
Feed Jan. 1-Apr. 30	ton	5.312	2.208	6.542	5.500
Feed June 16-Aug. 31	ton	.746	4.408	2.854	4.623
Corn silage	ha				.011
Feed June 16-Aug. 31	ton				.440
Soybean hay	ha	.293	.412	.200	.325
Feed Jan. 1-Apr. 30	ton	.626	.656	.197	.653
Feed June 16-Aug. 31	ton	.196	.219	.185	
Feed Sept. 1-Dec. 31	ton	.937	1.600	.815	1.295
Produce corn	ha	.043	.030	.063	.050
Feed May 1-June 15	ton	.129	.090	.189	.150
Harvest cassava leaves	ha	.050	.237	.257	.446
Feed Jan. 1-Apr. 30	ton	.043		.300	
Feed May 1-June 15	ton	.107	.110	.147	.150
Feed June 16-Aug. 31				.020	.172
Feed Sept. 1-Dec. 31			.602	.303	1.016
Feeding program cost	Bs.	583.10	809.67	697.34	924.95
Net return	Bs.	509.08	430.88	796.55	717.31
Annual capital used	Bs.	772.59	1157.77	1051.56	1469.92
Total land used	ha	1.790	1.901	1.638	1.769
Land in cultivated crops	ha	.423	.537	.397	.531

Table 12. The linear programming matrix for maximizing net revenue.

Row No.	Description	Unit	Feeding Program 1 1	Feeding Program 2 2	Feeding Program 3 3	Feeding Program 4 4	Feeding Program 5 5	Feeding Program 6 6
1	Net revenue	Bs.	381.26	376.58	291.97	245.17	420.05	414.36
2	Land	ha	1.145	1.072	.758	.775	1.375	1.287
3	Cows	cow	1	1	1	1	1	1
4	Owned capital	Bs.	281.85	219.48	499.40	269.37	330.20	254.33
5	Borrowed capital	Bs.						
6	Sale of hay	ha						
7	Sale of cassava	ha						
8	Cassava leaves	ha		.072				.087
9	Land in hay making	ha	.233	.353		.370	.250	.395
10	Land in silage making	ha	.024		.104		.029	
11	Land under cultivation	ha	.292	.220	.104		.337	.249

Table 12. (Continued)

Row No.	Description	Feeding Program 7 7	Feeding Program 8 8	Feeding Program 9 9	Feeding Program 10 10	Feeding Program 11 11	Feeding Program 12 12	Feeding Program 13 13
1	Net revenue	318.47	263.51	689.04	663.19	528.41	393.33	724.68
2	Land	.926	.917	1.216	1.082	.527	.433	1.447
3	Cows	1	1	1	1	1	1	1
4	Owned capital	677.10	309.53	572.62	372.18	777.00	455.17	640.78
5	Borrowed capital							
6	Sale of hay							
7	Sale of cassava							
8	Cassava leaves			.181	.385			.177
9	Land in hay making		.415	.039	.297		.336	.041
10	Land in silage making	.117		.078		.132		.089
11	Land under cultivation	.117		.327	.192	.132		.374

Table 12. (Continued)

Row No.	Description	Feeding Program 14 14	Feeding Program 15 15	Feeding Program 16 16	Feeding Program 17 17	Feeding Program 18 18	Feeding Program 19 19	Feeding Program 20 20
1	Net revenue	667.92	552.08	403.63	509.08	430.88	796.55	717.31
2	Land	.873	.744	.510	1.790	1.091	1.638	1.769
3	Cows	1	1	1	1	1	1	1
4	Owned capital	629.44	851.86	496.24	772.59	1157.77	1051.56	1469.92
5	Borrowed capital							
6	Sale of hay							
7	Sale of cassava							
8	Cassava leaves	.129			.050	.237	.257	.446
9	Land in hay making	.226		.378	.090	.158		.010
10	Land in silage making	.092	.144		.087	.095	.134	.155
11	Land under cultivation	.334	.144		.423	.537	.397	.530

Table 12. (Continued)

Row No.	Description	Produce Corn To Sell 21	Produce Grain Sorghum To Sell 22	Produce Soybeans To Sell 23	Produce Cassava Roots to Sell 24	Make hay To Sell 25	Buy more Cows 26	Borrow Capital 27
1	Net revenue	220.00	167.25	276.75	524.50	351.10		-0.09
2	Land	1	1	1	1	1		
3	Cows						-1	
4	Owned capital	236.65	215.48	151.83	783.42	546.80	1670.00	-1
5	Borrowed capital							
6	Sale of hay					1		
7	Sale of cassava				1			
8	Cassava leaves				-1			
9	Land in hay making					2		
10	Land in silage making							
11	Land under cultivation	1	1	1	1			

Table 12. (Continued)

Row No.	Description		Right Hand Side 150- ha Farm 28	Right Hand Side 150- ha Farm Silage Making Prohibited 29	Right Hand Side 150- ha Farm Cultivated Area Not Restricted 30	Right Hand Side 150- ha Farm Borrowed Capital Increased to 500,000 Bs. 31	Right Hand Side 300- ha Farm 32	Right Hand Side 450- ha Farm 33
1	Net revenue							
2	Land	≤	150	150	150	150	300	450
3	Cows	≤	80	80	80	80	130	200
4	Owned capital	≤	23,000	23,000	23,000	23,000	43,000	65,000
5	Borrowed capital	≤	147,000	147,000	147,000	500,000	261,000	396,000
6	Sale of hay	≤	20	20	20	20	20	20
7	Sale of cassava	≤	5	5	5	5	5	5
8	Cassava leaves	≤	0	0	0	0	0	0
9	Land in hay making	≤	70	70	70	70	70	70
10	Land in silage making	≤	20	0	20	20	20	20
11	Land under cultivation	≤	35	35	150	35	75	115

Table 13. Machinery and installation requirements for alternative enterprise organizations.

Item	Size	Price	Expected Lifetime Use
		Bolivares	Hours
Tractor	65 hp	24,000	10,000
Plow	3 disks	3,300	2,000
Disk	6 ft	5,800	2,000
Cultivator	2 row	2,550	2,000
Rotary Mower	6 ft	4,600	2,000
Planter	2 row	3,300	1,000
Fertilizer spreader (broadcast)	500 kg	1,600	2,000
Hay baler	standard	15,700	1,500
Hay rake (side delivery)	standard	4,500	2,000
Wagon	standard	3,500	4,000
Forage harvester	standard	11,000	1,500
Feed grinder (hammermill)	standard	4,000	1,500
Grinder and mixer for cassava roots	standard	2,200	1,500
Sprayer (row crop)	10 m	2,000	2,000
Silo (bunker)	100 ton	5,000	10 yr
Storage space for feed and grain	20 ton	2,500	20 yr
Milk barn	160 cows	20,000	20 yr
Irrigation pump and equipment (sprinkler type)	20 ha	75,000	10 yr
Drying floor (concrete)	100 m^2	1,300	20 yr

Table 14. Enterprise organizations for 150-, 300-, and 450-hectare dairy farms west of Lake Maracaibo, Venezuela; cows producing 4 and 6 liters per day; no cultivated crops.

Item	Unit	Farm System					
		1	2	7	8	10	11
Farm size	ha	150	150	300	300	450	450
Cows in production (bull calves marketed at 2 1/2 years of age)	cow	80	80	130	130	200	200
Avg. milk production/cow/day	liter	4	6	4	6	4	6
Feeding program							
Forage activities							
Maintain pastures only	ha	150	150	300	300	450	450
Concentrate activities							
Buy prepared concentrate	ton	87.12	120.40	141.57	195.65	217.80	301.00
Feed prepared concentrate							
Jan. 1-Apr. 30	ton	53.36	62.40	86.71	101.40	133.40	156.00
May 1-June 15	ton	6.88	11.76	11.18	19.11	17.20	29.40
June 16-Aug. 31	ton	10.48	17.92	17.03	29.12	26.20	44.80
Sept. 1-Dec. 31	ton	16.40	28.32	26.65	46.02	41.00	70.80
Buy molasses	ton	8.72	12.03	14.16	19.56	21.78	30.10
Feed molasses							
Jan. 1-Apr. 30	ton	5.34	6.24	8.67	10.14	13.34	15.60
May 1-June 15	ton	.69	1.17	1.12	1.91	1.72	2.94
June 16-Aug. 31	ton	1.05	1.79	1.70	2.91	2.62	4.48
Sept. 1-Dec. 31	ton	1.64	2.83	2.67	4.60	4.10	7.08

Table 15. Enterprise organization for a 150-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 4 liters per day; forage conserved as hay and silage (farm system 3).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 4 liters of milk per day (bull calves marketed at 2 1/2 years of age)	cow	100
Purchase of additional cows	cow	20
Forage Activities		
Maintain pastures only	ha	73
Maintain and fertilize pastures	ha	12.5
Maintain pastures and make hay two times	ha	15
Make forage sorghum silage	ha	2.5
Feed hay		
Jan. 1-Apr. 30	ton	77
June 16-Aug. 31	ton	58
Feed silage		
Jan. 1-Apr. 30	ton	131
June 16-Aug. 31	ton	46
Concentrate Activities		
Make soybean hay	ha	22
Feed soybean hay		
Jan. 1-Apr. 30	ton	14
June 16-Aug. 31	ton	10
Sept. 1-Dec. 31	ton	109
Harvest cassava leaves	ha	5
Feed cassava leaves Jan. 1-Apr. 30	ton	15
Buy prepared concentrate (feed Sept. 1-Dec. 31)	ton	.6
Buy molasses	ton	10.3
Feed molasses		
Jan. 1-Apr. 30	ton	0.3
Sept. 1-Dec. 31	ton	10.0
Buy urea-molasses mix	ton	9.0
Feed urea-molasses mix		
Jan. 1-Apr. 30	ton	2.9
June 16-Aug. 31	ton	0.1
Sept. 1-Dec. 31	ton	6.0
Cash Crop Activities		
Sale of fresh cassava roots	ha	5
Sale of hay	ha	20

Table 16. Enterprise organization for a 150-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 4 liters per day; forage conserved as hay (farm system 4).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 4 liters of milk per day (bull calves marketed at 2 1/2 years of age	cow	114
Purchase of additional cows	cow	34
Forage Activities		
Maintain pastures only	ha	73.2
Maintain and fertilize pastures	ha	15.5
Maintain pastures and make hay two times	ha	23
Feed hay		
Jan. 1-Apr. 30	ton	125
June 16-Aug. 31	ton	83
Concentrate Activities		
Make soybean hay	ha	14.3
Feed soybean hay		
Jan. 1-Apr. 30	ton	2.1
June 16-Aug. 31	ton	6.8
Sept. 1-Dec. 31	ton	76.9
Buy prepared concentrate (feed Sept. 1-Dec. 31)	ton	8.1
Buy molasses	ton	40.5
Feed molasses		
Jan. 1-Apr. 30	ton	5.8
Sept. 1-Dec. 31	ton	34.7
Buy urea-molasses mix	ton	36.8
Feed urea-molasses mix		
Jan. 1-Apr. 30	ton	15.4
June 16-Aug. 31	ton	2.0
Sept. 1-Dec. 31	ton	19.4
Cash Crop Activities		
Sale of fresh cassava roots	ha	5
Sale of hay	ha	12
Sale of corn	ha	7

Table 17. Enterprise organization for a 150-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 6 liters per day; no capital borrowing limitation (farm system 5).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 6 liters of milk per day (bull calves marketed at 2 1/2 years of age)	cow	68
Dairy cows producing 6 liters of milk per day (bull calves sold at 1 1/2 years of age)	cow	226
Purchase of additional cows	cow	214
Forage Activities		
Maintain pastures only	ha	24.2
Maintain and fertilize pastures	ha	78.7
Maintain pastures and make hay two times	ha	35
Make forage sorghum silage	ha	12.1
Feed hay		
Jan. 1-Apr. 30	ton	195
June 16-Aug. 31	ton	120
Feed silage		
Jan. 1-Apr. 30	ton	532
June 16-Aug. 31	ton	312
Concentrate Activities		
Buy corn (feed May 1-June 15)	ton	21
Buy grain sorghum (feed Jan. 1-Apr. 30)	ton	38
Buy prepared concentrate (feed Sept. 1-Dec. 31)	ton	52.5
Buy molasses	ton	267
Feed molasses		
Jan. 1-Apr. 30	ton	36
June 16-Aug. 31	ton	29
Sept. 1-Dec. 31	ton	202
Buy urea-molasses mix	ton	186
Feed urea-molasses mix		
Jan. 1-Apr. 30	ton	66
June 16-Aug. 31	ton	24
Sept. 1-Dec. 31	ton	96
Cash Crop Activities (none)		

Table 18. Enterprise organization for a 150-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 6 liters per day; no cultivated land limitation (farm system 6).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 6 liters of milk per day (bull calves marketed at 2 1/2 years of age)	cow	39
Dairy cows producing 6 liters of milk per day (bull calves sold at 1 1/2 years of age)	cow	41
Forage Activities		
Maintain and fertilize pastures	ha	23.5
Maintain pastures and make hay one time	ha	8.8
Maintain pastures and make hay two times	ha	6.2
Make forage sorghum silage	ha	4.1
Feed hay		
Jan. 1-Apr. 30	ton	56.8
June 16-Aug. 31	ton	37.4
Feed silage		
Jan. 1-Apr. 30	ton	188.0
June 16-Aug. 31	ton	95.2
Concentrate Activities		
Make soybean hay	ha	8.3
Feed soybean hay		
Jan. 1-Apr. 30	ton	.9
Sept. 1-Dec. 31	ton	48.8
Produce corn	ha	1.1
Feed ground ear corn May 1-June 15	ton	3.3
Harvest cassava leaves	ha	5
Feed cassava leaves		
Jan. 1-Apr. 30	ton	5
Sept. 1-Dec. 31	ton	10
Buy corn (feed May 1-June 15)	ton	3.8
Buy grain sorghum (feed Jan. 1-Apr. 30)	ton	6.6
Buy prepared concentrate (feed Sept. 1-Dec. 31)	ton	7.9
Buy molasses	ton	39.5
Feed molasses		
Jan. 1-Apr. 30	ton	6.4
June 16-Aug. 31	ton	5.0
Sept. 1-Dec. 31	ton	28.1
Buy urea-molasses mix	ton	27.5
Feed urea-molasses mix		
Jan. 1-Apr. 30	ton	10.1
June 16-Aug. 31	ton	4.2
Sept. 1-Dec. 31	ton	13.2

Table 18. (Continued)

Description	Unit	Quantity
Cash Crop Activities		
Sale of fresh cassava roots	ha	5
Sale of baled hay	ha	20
Sale of corn	ha	73

Table 19. Enterprise organization for a 300-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 4 liters per day; forage conserved as hay and silage (farm system 9).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 4 liters of milk per day (bull calves marketed at 2 1/2 years of age)	cow	203
Purchase of additional cows	cow	73
Fattening of purchased bulls (six month fattening program)	head	25
Forage Activities		
Maintain pastures only	ha	175
Maintain and fertilize pastures	ha	18.3
Maintain pastures and make hay two times	ha	26.5
Make forage sorghum silage	ha	6
Feed hay		
Jan. 1-Apr. 30	ton	107
June 16-Aug. 31	ton	131
Feed silage		
Jan. 1-Apr. 30	ton	413
June 16-Aug. 31	ton	19
Concentrate Activities		
Make soybean hay	ha	59.7
Feed soybean hay		
Jan. 1-Apr. 30	ton	80.8
June 16-Aug. 31	ton	26.2
Sept. 1-Dec. 31	ton	251.4
Produce corn	ha	1
Feed ground ear corn May 1-June 15	ton	3
Harvest cassava leaves	ha	5
Feed cassava leaves		
Jan. 1-Apr. 30	ton	12.3
May 1-June 15	ton	2.7
Cash Crop Activities		
Sale of fresh cassava roots	ha	5.0
Sale of baled hay	ha	8.5

Table 20. Enterprise organization for a 450-hectare dairy farm west of Lake Maracaibo, Venezuela; cows producing 4 liters per day; forage conserved as hay and silage (farm system 12).

Description	Unit	Quantity
Cattle Activities		
Dairy cows producing 4 liters of milk per day (bull calves marketed at 2 1/2 years of age)	cow	341
Purchase of additional cows	cow	141
Fattening of purchased bulls (six month fattening program)	head	26
Forage Activities		
Maintain pastures only	ha	271
Maintain and fertilize pastures	ha	41
Maintain pastures and make hay two times	ha	35
Make forage sorghum silage	ha	16
Feed hay		
Jan. 1-Apr. 30	ton	138
June 16-Aug. 31	ton	177
Feed silage		
Jan. 1-Apr. 30	ton	911
June 16-Aug. 31	ton	225
Concentrate Activities		
Make soybean hay	ha	81
Feed soybean hay		
Jan. 1-Apr. 30	ton	113.5
June 16-Aug. 31	ton	34.5
Sept. 1-Dec. 31	ton	338.0
Produce corn	ha	1
Feed ground ear corn May 1-June 15	ton	3
Harvest cassava leaves	ha	5
Feed cassava leaves		
Jan. 1-Apr. 30	ton	12.2
May 1-June 15	ton	2.8
Buy prepared concentrate (feed Sept. 1-Dec. 31)	ton	1.3
Buy molasses (feed Sept. 1-Dec. 31)	ton	28.1
Buy urea-molasses mix	ton	33.4
Feed urea-molasses mix		
Jan. 1-Apr. 30	ton	10.1
Sept. 1-Dec. 31	ton	23.3
Cash Crop Activities		
Sale of fresh cassava roots	ha	5

Table 21. Sensitivity analysis for the minimum cost feeding programs; cows producing 4 liters and 6 liters per day; bull calves marketed at 2 1/2 years of age.

Item	Unit	Optimum Solution		Cost per Unit	Percentage Change in Cost per Unit for Activity to Enter or Leave the Solution	
		4 liter cows	6-liter cows	Bolivares	4-liter cows	6-liter cows
Maintain pastures	ha	.810	1.052	94.00	37	37
Fertilize pastures	ha	.103		402	19	38
Irrigate pastures	ha			671.00	29	30
Fertilize and irrigate	ha			883.00	34	49
Make hay (one time)	ha			400.20	6	6
Fertilize and make hay (one time)	ha			636.20	12	33
Irrigate and make hay (one time)	ha			977.20	21	22
Fertilize, irrigate and make hay (one time)	ha			1,087.20	30	42
Make hay (two times)	ha	.125	.21	671.40	2	3
Fertilize and make hay (two times)	ha			835.40	12	27
Irrigate and make hay (two times)	ha			1,248.40	14	15
Make silage (one time)	ha			464.20	32	33
Fertilize and make silage (one time)	ha			700.20	27	46
Irrigate and make silage (one time)	ha			1,041.20	30	31
Fertilize, irrigate and make silage (one time)	ha			1,161.20	38	50
Make silage (two times)	ha			799.40	28	29

Table 21. (Continued)

Item	Unit	Optimum Solution		Cost per Unit	Percentage Change in Cost per Unit for Activity to Enter or Leave the Solution	
		4-liter cows	6-liter cows	Bolivares	4-liter cows	6-liter cows
Fertilize and make silage (two times)	ha			963.40	33	47
Irrigate and make silage (two times)	ha			1,376.40	28	30
Green chop during dry season	ha			1,402.00	11	17
Fertilize and green chop	ha			1,690.00	17	29
Make hay (one time) and green chop	ha			1,673.20	8	13
Fertilize, green chop, and make hay (one time)	ha			1,913.20	18	28
Make hay (two times) and green chop	ha			2,001.40	9	13
Make silage (one time) and green chop	ha			1,722.20	13	18
Fertilize, green chop, and make silage (two times)	ha			1,962.20	22	32
Make silage (two times) and green chop	ha			2,129.40	18	22
Make hay (one time) and deferred graze	ha			496.20	26	30
Make silage (one time) and deferred graze	ha			560.20	44	48
Fertilize and make silage (one time and custom hired)	ha			946.20	48	
Green chop during entire year	ha			2,729.00	38	36

Table 21. (Continued)

Item	Unit	Optimum Solution		Cost per Unit	Percentage Change in Cost per Unit for Activity to Enter or Leave the Solution	
		4-liter cows	6-liter cows	Bolivares	4-liter cows	6-liter cows
Green chop using forage sorghum	ha			2,566.75		39
Forage sorghum silage (feed Jan. 1-Apr. 30)	ha	.029	.060	1,701.85	3	3
Forage sorghum silage (feed June 16-Aug. 31)	ha		.030	1,701.85	1	6
Forage sorghum silage (custom hired and fed Jan. 1-Apr. 30)	ha			2,562.85	34	34
Make corn silage (feed Jan. 1-Apr. 30)	ha			1,051.20	5	4
Make corn silage (feed June 16-Aug. 31)	ha			1,051.20	11	8
Produce corn (feed Jan. 1-Apr. 30)	ha			893.00		47
Produce corn (feed May 1-June 15)	ha		.008	908.00		27
Produce corn (feed Sept. 1-Dec. 31)	ha			938.00	33	
Produce grain sorghum (feed Jan. 1-Apr. 30)	ha			924.00	46	39
Produce grain sorghum (feed May 1-June 15)	ha					22
Produce grain sorghum (feed June 16-Aug. 31)	ha			961.50	50	48

Table 21. (Continued)

Item	Unit	Optimum Solution		Cost per Unit	Percentage Change in Cost per Unit for Activity to Enter or Leave the Solution	
		4-liter cows	6-liter cows	Bolivares	4-liter cows	6-liter cows
Produce grain sorghum (feed Sept. 1-Dec. 31)	ha			980.25	28	12
Produce soybean hay (feed Jan. 1-Apr. 30)	ha	.078	.051	674.25	9	11
Produce soybean hay (feed June 16-Aug. 31)	ha	.020	.037	734.25	9	7
Produce soybean hay (feed Sept. 1-Dec. 31)	ha	.210	.189	764.25	8	10
Buy grain sorghum (feed Sept. 1-Dec. 31)	ton			400.00		46
Buy molasses (feed Sept. 1-Dec. 31)	ton			200.00	16	3
Buy urea-molasses mix (feed Jan. 1-Apr. 30)	ton			250.00	28	31
Buy urea-molasses mix (feed June 16-Aug. 31)	ton			250.00	30	29
Buy urea-molasses mix (feed Sept. 1-Dec. 31)	ton			250.00	40	33
Harvest cassava leaves (feed Jan. 1-Apr. 30)	ha		.053	558.30	12	40
Harvest cassava leaves (feed May 1-June 15)	ha		.034	573.30		89
Harvest cassava leaves (feed June 16-Aug. 31)	ha			588.30	9	7
Harvest cassava leaves (feed Sept. 1-Dec. 31)	ha		.090	603.30	15	3

Table 21. (Continued)

Item	Unit	Optimum Solution		Cost per Unit	Percentage Change in Cost per Unit for Activity to Enter or Leave the Solution	
		4-liter cows	6-liter cows	Bolivares	4-liter cows	6-liter cows
Produce cassava roots (feed Jan. 1-Apr. 30) and harvest cassava leaves (feed Jan. 1-Apr. 30)	ha			1,758.80	41	36
Produce cassava roots (feed Jan. 1-Apr. 30) and harvest cassava leaves (feed May 1-June 15)	ha			1,773.80		47
Produce cassava roots (feed Jan. 1-Apr. 30) and harvest cassava leaves (feed June 16-Aug. 31)	ha			1,788.80	45	43
Produce cassava roots (feed Jan. 1-Apr. 30) and harvest cassava leaves (feed Sept. 1-Dec. 31)	ha			1,803.80	19	4

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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August, 1972

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